Cut Flowers and Greens

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Botany and Introduction: Plant materials from a wide range of taxa are grown and harvested as cut flowers or florist greens; these include ferns and lycopods, gymnosperms and angiosperms. Because of this diversity, these guidelines include a general review of postharvest requirements for cut ornamentals, followed by brief summaries of the requirements of a range of the most common materials used in commercial floriculture. The references cited are usually the most recent report on a particular crop, and therefore provide an entrée to the literature that is the basis for the recommendations.

Quality Characteristics and Criteria: Cut ornamentals are complex plant organs, in which loss of quality of stems, leaves, or flower parts may result in rejection in the marketplace. In some ornamentals, loss of quality may result from one of several causes, including wilting or abscission of leaves and/or petals, yellowing of leaves, and geotropic or phototropic bending of scapes and stems. In evaluating factors that affect the life of ornamentals and how to maximize their market life, it is important first to understand the diverse causes of quality loss.

Growth, development, and aging. The whole plant and its individual organs are an integral part of the plant's life cycle. Even when there is no senescence of floral organs or leaves, continued growth can result in quality loss: eg., in spike-type flowers that bend in response to gravity.

Flower senescence. The early death of flowers and greens is a common cause of quality loss and reduced vase-life for many ornamentals. Flowers can be divided into several categories on the basis of their senescence. Some flowers are extremely long-lived, especially in the Asteraceae and Orchidaceae families, while others are short-lived, including many of the bulb crops, like Tulip, Iris, and Narcissus.

Wilting. Extended life for cut ornamentals depends absolutely on a continuing and adequate supply of water. Rapid wilting of shoot tips, leaves, and petals results from an obstruction of the water supply through the cut stems.

Leaf yellowing and senescence. Yellowing of leaves and other organs (buds, stems) is commonly associated with the end of display life in some flowers; alstroemeria being an important example (Hicklenton, 1991). Leaf yellowing is a complex process that may be caused by a range of different environmental factors.

Shattering. Abscission and loss of leaves, buds, petals, flowers, or even branchlets is a process called 'shattering', and it is a common problem in cut flowers and potted plants (van Doorn and Stead, 1997). Very often, this problem is associated with the presence of ethylene in the air, but other environmental factors may also be involved.

Factors Affecting Postharvest Quality: Maintaining the freshness of cut flowers and other ornamentals requires an understanding of the factors that lead to their deterioration. A number of these factors are different from those that apply to the edible crops covered in this handbook. Nevertheless, understanding these factors allows us to develop and implement optimum postharvest handling technologies.

Variety. Many commercial cut flowers and cut greens are patented cultivars, characterized by specific attributes such as color, form, disease resistance, and size. Sometimes, breeders fail to consider other commercially important attributes. For example, some of the modern alstroemeria cultivars have wonderful flowers, but their display life is short because of rapid leaf yellowing under commercial conditions. There is relatively little published information comparing the postharvest life of different ornamental cultivars (Van Der Meulen-Muisers et al., 1999).

Preharvest factors. What goes on in the greenhouse or field is an important determinant of the

quality and life of cut flowers and foliage (Celikel and Karaaly, 1995a). Disease free plants that were properly irrigated and fertilized will produce flowers that look better and perform better in the vase. However, the large leaves on roses grown under supplementary light with CO_2 fertilization make them more susceptible to postharvest wilting.

Food Supply. Starch and sugars stored in the stem, leaves and petals provide much of the food needed for cut-flower opening and maintenance. The levels of these carbohydrates are highest when plants are grown in high light with proper cultural management. Carbohydrate levels are, in fact, generally highest in the late afternoon: after a full day of sunlight. However, flowers are preferably harvested in the early morning, because temperatures are lower, plant water content is higher, and a whole day is available for processing the cut flowers.

The quality and vase-life of many cut flowers can be improved by pulsing them immediately after harvest with a sugar solution. Pulsing is done by standing the cut flowers in the solution for a short period, usually less than 24 h, and often at low temperature. Typical examples include tuberose, where storage-life and opening are dramatically improved; gladiolus, where flowers open further up the spike, are bigger, and have a longer vase-life; and sweet peas, where vase-life was improved (Ichimura and Suto, 1999). Sugar is also an important part of the bud-opening solution used to open bud-cut flowers before distribution (Kuiper et al., 1995), and as part of the vase solution used at the retail and domestic level. Potted plants are able to provide their own food supply through photosynthesis if they are held in adequate light conditions.

Light. The presence or absence of light during storage is generally not a concern, except in cases where yellowing of foliage is a problem. The leaves of certain cultivars of chrysanthemum, alstroemeria, marguerite daisy and other crops can yellow if stored in darkness at warm temperatures. The blackening of leaves of cut *Protea nerifolia* flowers can be prevented by maintaining them in high light or by giving them a sugar pulse. This suggests that the problem is induced by low carbohydrate status in the harvested inflorescence (Bieleski et al., 1992).

Water Supply. Cut flowers, especially those with large leaf areas, lose water and wilt very rapidly. They should be stored above 95% RH to minimize water loss, particularly during long-term storage. Water loss is dramatically reduced at low temperatures, another reason for prompt and efficient cooling of cut flowers and potted plants. Even after flowers have lost considerable water (for example during transportation or storage) they can be fully rehydrated using proper techniques. Cut flowers will absorb solutions without difficulty providing there is no obstruction to water flow in the stems. Air embolism, plugging with bacteria, plant debris or dirt, and poor water quality reduce solution uptake (van Doorn, 1999).

i. Air embolism. Air embolisms occur when small bubbles of air (emboli) are drawn into the stem at the time of cutting. These bubbles cannot move far up the stem, so the upward movement of solution to the flower may be restricted. Emboli may be removed in many ways; e.g., recutting the stems under water (removing about 2 cm), ensuring that the solution is acid (pH 3 or 4), placing the stems in a vase solution heated to 40ºC (warm, but not hot) or in an ice-cold solution (0ºC), placing the stems in deep (>20cm) water, or treating the flowers with a detergent 'pulse'.

ii. Bacterial plugging. The cut surface of a flower stem releases the contents of the cut cells (ie., proteins, amino acids, sugars, and minerals) into the vase water. These are ideal food for bacteria, yeasts, and fungi, which grow rapidly in the anaerobic environment of the vase. Slime produced by the bacteria, and the bacteria themselves, can obstruct the water-conducting system. This problem must be addressed at every step of the postharvest chain by:

Using clean water for making postharvest solutions
Cleaning and disinfecting buckets
Using white buckets - dirt is easier to see in a white bucket.
Including a biocide in all bucket and vase solutions. Ca(OCl)2, NaOCl ('Clorox'), Al2(SO4)3, and salts of 8-hydroxyquinoline are commonly used bactericides. An acidic solution also inhibits

bacterial growth.

iii. Hard Water. Hard water frequently contains minerals that make the water alkaline (high pH). Water movement in flower stems is drastically reduced when the water is of high pH. This problem can be overcome either by removing minerals from the water (by using a deionizer, still, or reverse osmosis system) or by making the water acid (ca. pH 3.5). Citric acid is commonly used as a safe acidulant.

Water Quality. Chemicals commonly found in tap water are toxic to some ornamentals. Sodium (Na), present in high concentrations in soft water, is toxic to carnations and roses and will cause salt burn (burning of the leaf tips and margins) in potted plants. Fluoride (F) is very toxic to gaillardia (Rajitha et al., 1999), gerbera, gladiolus, roses and freesia. Fluoridated drinking water contains enough F (about 1 ppm) to damage these flowers.

Growth Tropisms. Certain responses of cut flowers to environmental stimuli (tropisms) can result in quality loss. Most important is geotropism (bending away from gravity) and phototropism (bending towards light). Geotropism often reduces quality in spike-flower crops like gladiolus, snapdragon, lisianthus, and gerbera, because the flowers and spike bend upward when stored horizontally (Philosoph et al., 1995). These flowers should be handled upright whenever possible.

Mechanical Damage. Physical abuse of cut flowers and foliage results in torn petals, damaged leaves, broken stems. Obvious injuries are undesirable for aesthetic reasons, and disease organisms can more easily infect plants through injured areas. Additionally, respiration and ethylene evolution are generally higher in injured tissues, further reducing storage and vase-life.

Horticultural Maturity Indices: Minimum harvest maturity for most cut flowers is the stage at which harvested buds can be opened fully and have satisfactory display life after distribution. Many flowers are best cut in the bud stage and opened after storage, transport or distribution. This technique has many advantages, including reduced growing time for single-harvest crops, increased product packing density, simplified temperature management, reduced susceptibility to mechanical damage and reduced desiccation. Many flowers are presently harvested when the buds are starting to open (rose, gladiolus), although others are normally fully open or nearly so (chrysanthemum, carnation). Flowers for local markets are generally harvested much more open than those intended for storage and/or long-distance transport. Cut foliage is harvested when the uppermost leaves are fully expanded to avoid postharvest wilting of the shoot tips.

Grades, Sizes and Packaging: The designation of grade standards for cut flowers is one of the most controversial areas in their care and handling. Objective standards such as stem length, which is still the major quality standard for many flowers, may bear little relationship to flower quality, vase-life or usefulness. Weight of the bunch for a given length is a method that has been shown to strongly reflect flower quality. Straightness of stems, stem strength, flower size, vase-life, freedom from defects, maturity, uniformity, and foliage quality are among the factors that should also be used in cut flower grading. If used, mechanical grading systems should be carefully designed to ensure efficiency and to avoid damaging the flowers.

Flowers are normally bunched, except for anthuriums, orchids and some other specialty flowers. The number of flowers in the bunch varies according to growing area, market and flower species. Groups of 10, 12, and 25 are common for single-stemmed flowers. Spray-type flowers are bunched by the number of open flowers, by weight or by bunch size. Bunches are held together by string, paper-covered wire or elastic bands and are frequently sleeved soon after harvest to unitize the bunch, protect the flower heads, prevent tangling, and identify the grower or shipper. Materials used for sleeving include paper (waxed or unwaxed), corrugated card (smooth side towards the flowers) and polyethylene (perforated, unperforated and blister). Sleeves can be preformed (although variable bunch size can be a problem), or they can be formed around each bunch using tape, heat-sealing (polyethylene), or staples.

There are many shapes of packing containers for cut flowers, but most are long and flat. This design restricts the depth to which the flowers can be packed in the box, and this may reduce physical damage. In addition, flower heads can be placed at both ends of the container for better use of space. With this kind of flower placement, whole layers of newspaper are often used to prevent the layers of flowers from injuring each other. The use of small pieces of newspaper to protect only the flower heads, however, is probably the better practice, since it allows for more efficient cooling of flowers after packing. It is critically important that containers be packed in such a way that transport damage is minimized. Some packers anchor the product by using enough flowers and foliage in the box so that flowers in the package, after banding, are immobilized by the surrounding material. To avoid longitudinal slip, packers in many flower-producing countries use one or more "cleats". These are normally foam- or newspaper-covered wood pieces that are placed over the product, pushed down, and stapled into each side of the box. Padded metal straps, elastic bands, high density polyethylene blocks, and cardboard tubes can also be used as cleats. The heads of the flowers should be placed 6 to 10 cm (2.4 to 4 in) from the end of the box to allow effective pre-cooling and to eliminate the danger of petal bruising should the contents of the box shift.

Gladioli, snapdragons and some other species are often packed in vertical hampers to prevent geotropic curvature that reduces their acceptability. Cubic hampers are used for upright storage of daisies and other flowers. A new packaging system, the 'Procona' system, uses plastic bases and a cardboard sleeve to allow transport of flowers upright in water. This system is more expensive than traditional boxes, and less product can be packed in it, but the presence of water, may improve flower quality when they are not transported under proper temperature conditions.

Specialty flowers such as anthurium, orchid, ginger, and bird of paradise are packed in various ways to minimize friction damage during transport. Frequently, flower heads are individually protected by paper or polyethylene sleeves. Cushioning materials such as shredded paper and paper or wood wool may be placed between packed flowers to further reduce damage.

Pre-cooling Conditions: By far the most important part of maintaining the quality of harvested flowers is ensuring that they are cooled as soon as possible after harvest and that optimum temperatures are maintained during distribution. Most flowers should be held at 0 to 1 °C (32 to 33.8 °F). Chilling-sensitive flowers (anthurium, bird of paradise, ginger, tropical orchids) should be held at temperatures above 10 °C (50 °F).

Once packed, cut flowers are difficult to cool. Their high rate of respiration and the high temperatures of most greenhouses and packing areas result in heat build-up in packed flower containers unless measures are taken to ensure temperature reduction. It is therefore necessary to cool the flowers as soon as possible after packing. Individually, flowers cool (and warm) rather rapidly (half-cooling times of a few min). However, individual flowers brought out of cool storage into a warmer packing area will warm quickly and water will condense on the flower. The simplest method of ensuring that packed flowers are adequately cooled and dry is to pack them in the cool room. Although this method is not always popular with packers, and may increase labor cost and slow down packing somewhat, it will ensure a cooled, dry product.

Forced-air cooling of boxes with end holes or closeable flaps is the most common and effective method for pre-cooling cut flowers. Cool air is sucked or blown through the boxes. Care must be taken to pack them so that air can flow through the box and not be blocked by the packing material or flowers. In general, packers use less paper when packing flowers for pre-cooling. The half-cooling time for forced-air cooling ranges from 10 to 40 min, depending on product and packaging. Flowers should be cooled for three half-cooling times (by which time they are 7/8 cool) (See section on temperature).

If the packages are to remain in a cool environment after pre-cooling, vents may be left open to assist removal of the heat of respiration. Flowers that are to be transported at ambient temperatures can be packed in polyethylene caskets, foam-sprayed boxes or boxes with the vents resealed. Ice that is used after pre-cooling is only effective if placed to intercept heat entering the carton (ie., it must surround the product), and care must be taken to ensure that the ice does not melt onto flowers or cause chilling

damage. Pre-cooling of vertical hampers or Proconas presents a particular challenge, but can be achieved using a 'tunnel' forced-air cooling system.

Chilling Sensitivity: Some tropical crops such as anthurium, bird of paradise, some orchids, ginger and many foliage plants are injured at temperatures below 10 °C (50 ºF). Symptoms of "chilling injury" include darkening of the leaves and petals, water soaking of the petals, and, in severe cases, collapse and drying of leaves and petals. Special care needs to be taken with tropical flowers shipped in a mixed load. The flowers should be packed in plenty of insulating material (an insulated box packed with shredded newsprint, for example). These flowers should not be pre-cooled. If they are to be shipped by refrigerated truck, they should be placed in the middle of the load, away from direct exposure to cooling air.

Ethylene Production and Sensitivity: A number of flowers, especially carnations, gypsophila and some rose cultivars, senesce rapidly if exposed to minute concentrations of ethylene gas. A number of flowers (like carnations and sweet peas) produce ethylene as they age and this endogenous ethylene is involved in the death of the flower. Other flowers, such as snapdragon, and delphinium, produce little ethylene themselves, but exogenous ethylene causes flower abscission (or shattering). Concentrations of ethylene above 100 ppm ($nl \cdot l^{-1}$) in the vicinity of sensitive ornamentals can cause damage and therefore should be avoided. Storage and handling areas should be designed not only to minimize contamination of the atmosphere with ethylene, but should also have adequate ventilation to remove any ethylene contamination that may occur. Treatment with the anionic thiosulfate complex of silver (STS) or with 1-methylcyclopropene (1-MCP; marketed in North America as EthylBloc®) inhibits the deleterious effects of ethylene whether a product of atmospheric contaminant (exogenous) or produced by the flower (endogenous) (Macnish et al., 2000). Finally, refrigerated storage is beneficial in that both ethylene production and sensitivity are reduced greatly when temperatures are low.

Optimum Storage Conditions: The vase-life of flowers that are stored even for a few days is closely correlated with their respiration during storage. Rapid cooling and proper refrigeration are thus essential to maintain quality and satisfactory vase-life of cut flowers and foliage. The recommended conditions for commercial storage of most cut flowers are 0 to 1 ºC (32 to 33.8 °F) at 95 to 99% RH. Although flowers are commonly held in water for short-term storage, better vase-life after longer storage is achieved by storing the flowers dry. Under these conditions, stable temperatures (to reduce condensation and *Botrytis* infection), and high RH are essential. Flowers for longer-term storage are typically wrapped in newsprint (to absorb any condensation) and perforated polyethylene (to reduce water loss). Storage-life varies by species, but is typically less than 3 weeks.

Controlled Atmosphere (CA) Considerations: There have been relatively few reported benefits of CA storage for cut flowers. Any consideration of the use of CA must follow achievement of proper temperature control and elimination of the effects of *Botrytis* during storage. Recommended atmospheres vary from pure nitrogen (daffodils) to more conventional atmospheres (carnations).

Retail Outlet Display Considerations: The simple way to ensure rapid re-hydration of all but the most difficult or desiccated flowers is to re-cut the stems and place them in a clean bucket of water containing a quality flower preservative solution *in the cooler.* The pH of the preservative solution should be below 5. For badly wilted flowers a re-hydration solution may be helpful, since the sugar in vase preservatives reduces the flow of water in stems. Flowers with woody branches respond particularly well to low pH (3.5 is optimal), and some flowers (sunflowers, astilbe) respond well to a 10 min 'pulse' with a 0.02% detergent solution. Flower coolers should be < 5 °C (41 °F); flowers should be placed in the coolers when not on display or being used for preparing arrangements.

Respiration Rates: Cut flowers have extremely high rates of respiration, and respiration increases

exponentially with temperature (Table 1) with Q_{10} values that range from 1.5 to as high as 7. Different cultivars of the same species may have quite different respiration rates and may respond differently to temperature.

Table 1. Q_{10} values, respiration rates (ml CO_2 kg^{-1} h^{-1}) and equations relating respiration to storage temperature of selected cut flower species and cultivars. To get mg kg^{-1} h^{-1}, multiply the mg kg^{-1} h^{-1} rate by 1.9. To calculate heat production, multiply mg CO_2 kg^{-1} h^{-1} by 220 to get BTU per ton per day or by 61 to get kcal per metric ton per day. Data from Cevallos, 1998.

	Q_{10} 0 to 10	**Q_{10} 10 to 20**	**Respiration**	**Respiration/temperature**	**r^2**
Flower species/cultivar	**ºC**	**ºC**	**10 ºC**	**Equation (r =)**	
Anemone 'Mona Lisa'	3.08	2.45	163.0	$28.137e^{0.110t}$	0.999
Aster 'Matsumoto'	3.16	2.90	117.3	$19.613e^{0.114t}$	0.999
Calla Lily	2.95	2.21	62.8	$12.105e^{0.093t}$	0.991
Carnation 'Imperial White'	3.10	2.66	133.9	$22.733e^{0.109t}$	0.997
Carnation 'Ruri'	4.46	2.78	145.2	$19.433e^{0.127t}$	0.987
Carnation 'White Sim'	2.05	2.56	100.5	$25.369e^{0.082t}$	0.993
Daffodil 'King Alfred'	6.76	2.97	151.5	$14.302e^{0.173t}$	0.973
Gerbera	2.94	2.88	125.4	$22.144e^{0.110t}$	0.997
Iris 'Madonna'	3.22	3.28	101.6	$17.758e^{0.112t}$	0.991
Iris 'Telstar'	3.37	2.76	83.5	$14.257e^{0.110t}$	0.994
Killian Daisy	2.97	2.30	86.7	$15.63e^{0.109t}$	0.999
Lisianthus	3.67	3.44	67.3	$10.521e^{0.124t}$	0.993
Jonquil 'Geranium'	3.86	2.85	174.7	$25.061e^{0.130t}$	0.995
Narcissus 'Paperwhite'	3.48	2.61	146.6	$22.221e^{0.125t}$	0.999
Ranunculus	3.13	2.24	236.1	$43.395e^{0.095t}$	0.989
Rose 'Ambiance'	4.13	3.85	109.9	$14.262e^{0.138t}$	0.997
Rose 'Cara Mia'	5.74	3.17	134.0	$12.912e^{0.149t}$	0.987
Rose 'Fire and Ice'	5.35	3.05	155.7	$17.154e^{0.141t}$	0.987
Rose 'First Red'	5.67	3.00	108.0	$9.3104e^{0.16t}$	0.964
Rose 'Kardinal'	4.11	2.71	149.9	$21.115e^{0.121t}$	0.990
Rose 'Preference'	4.82	4.76	59.1	$6.0271e^{0.161t}$	0.979
Rose 'Raphaella'	2.40	1.54	128.3	$27.253e^{0.089t}$	0.995
Rose 'Tineke'	2.39	2.78	73.0	$14.726e^{0.097t}$	0.991
Snapdragon	2.65	2.53	210.5	$39.802e^{0.1t}$	0.995
Statice	2.87	4.77	65.0	$10.587e^{0.132t}$	0.988
Tulip	3.32	2.98	180.0	$28.975e^{0.117t}$	0.999

Physiological Disorders: There are relatively few recognized physiological disorders in the postharvest life of cut flowers and foliage. "Topple" of tulips, a collapse of the scape, is a disorder associated with low calcium status of the flowers. Petal blackening in some red roses has been suggested also to be associated with inadequate calcium and perhaps boron nutrition.

Postharvest Pathology: Flowers are very susceptible to disease, not only because their petals are fragile, but also because the secretions of their nectaries often provide an excellent nutrient supply for even mild pathogens. Transfer from cold storage to warmer handling areas often results in condensation of water on the harvested flowers. The most commonly encountered disease organism, gray mold (*Botrytis cinerea*), can germinate wherever free moisture is present. In the humid environment of the flower head, it can even grow, albeit more slowly, at near freezing. Proper greenhouse hygiene management (Hammer and

Evensen, 1996), temperature control, and minimizing condensation on harvested flowers reduce losses caused by this disease.

Quarantine Issues: Export of cut flowers to other markets requires phytosanitary certification. A number of pests on cut flowers are the subject of quarantine regulations in a number of overseas markets. Disinfestation of quarantine insects in cut flowers is the subject of active research.

Suitability as Fresh-cut Product: There is a small market for edible flowers, and some high-value fresh-cut salads include petals in the mix. Obviously chemicals not registered for food use may not be used in postharvest handling of flowers intended as food.

Special Considerations: Many special considerations that arise from the unique physiology, handling and marketing of cut flowers and foliage are addressed below for the individual crops.

Guidelines for Individual Crops:

ANEMONE, WINDFLOWER

Scientific Name and Introduction: *Anemone spp.* Brightly colored in deep reds, blues, purples, and white, anemones have rather short stems, and are typically a Spring flower. New, improved tetraploid varieties have recently been introduced into commerce (Jacob et al., 1997). Anemone is an ancient Greek name meaning windflower from 'anemos' for wind.

Quality Characteristics and Criteria: Flowers should be harvested when the buds are fully colored and 25 to 50% open, but before the petals have expanded and the pollen is shed. Purchase when true colors are showing.

Grading and Bunching: Anemones are normally sold in bunches of 10 stems.

Ethylene Sensitivity: Ethylene exposure causes petal shatter and reduced vase-life.

Pretreatments: Pretreatment with STS or MCP prevents the deleterious effects of ethylene.

Storage Conditions: Anemones should be stored at 0 to 1 ºC (32 to 33.8 °F), and may be dry-stored for at least 1 week Store in a vertical position.

Packing: The flowers are usually packed in standard horizontal fiberboard boxes.

Special Considerations: Anemone's prominence and beauty in arrangements is a double-edged sword because of the flower's relatively short vase-life. It is preferable not to use anemones as focal points. Keep stems wrapped during re-hydration to help keep them straight. There is no scientific basis for the practice of piercing a hole through the flower base to extend life. Placing anemones in vases with freshly cut daffodils can reduce their life because of the harmful juices exuded from the daffodils.

ANTHURIUM, FLAMINGO FLOWER

Scientific Name and Introduction: *Anthurium andraeanum* With their brilliant glossy spathes (the brightly colored ornamental part of the flower), and slender spadices, anthuriums are classic tropical flowers. New cultivars provide a wide range of colors and forms, and their vase-life can be very long. The elegant blooms of this tropical aroid are produced and sold throughout the world. The true flowers are found on the "spadix", the upright organ in the center of the "spathe," which is the decorative petal-like organ surrounding the spadix. Although anthuriums are sensitive to low temperatures, they have a long vase-life when properly handled. The end of their vase-life is usually the result of inability to draw water from the vase solution, and is associated with loss of glossiness and then blueing of the spathe. Most of the water lost by the flower evaporates from the spadix. Application of wax, to prevent this water loss or pulsing with silver nitrate to improve water relations of the flower, can extend their vase-life considerably. Anthurium is also known as Tailflower.

Quality Characteristics and Criteria: Maturity of anthurium flowers is determined by the proportion of open flowers on the spadix. In immature anthuriums, the spadix is smooth. Flower opening starts at the

base of the spadix and proceeds upwards; spadices with open flowers are noticeably rough. Although producers in some countries harvest anthuriums when as little as 20% of the spadix is rough, Hawaiian growers harvest flowers when only 25% of the spadix is still smooth (75% of the flowers are therefore open). Harvesting anthuriums when more mature increases overall vase-life. Avoid flowers that show any signs of chilling injury (purpling of the spathe, browning or wilting of the spadix). For maximum life, flowers should be purchased when the spadix, the slender 'tail' of the flower, is 50 to 75% rough. The spadix is the true inflorescence of the anthurium, and the rough mature flowers are easily distinguished from the smooth, immature flowers.

Grading and Bunching: Although there are no formal grade standards for anthuriums, top quality implies long stems, uniformity of color and size, proper maturity, glossiness of the spathe, and freedom from any damage or disease. Anthuriums are normally packed individually.

Ethylene Sensitivity: Anthuriums are not affected by exposure to ethylene, and anti-ethylene treatments provide no benefit.

Pretreatments: Some researchers recommend pretreatment to increase the vase-life of anthuriums, but some cultivars (e.g. 'Osaki') achieve maximum vase-life with DI alone. It seems probable that vase-life problems are associated with bacterial contamination of the cut stem bases. If anthuriums are placed in water after harvest, a biocide, eg., 50 ppm hypochlorite, should be added. Either: Pulse the re-cut stems for 10 to 20 min in 1000 ppm silver nitrate. (Rinse stems with fresh water after treatment). Or: Dip the whole flower in an emulsion of Carnuba wax. One suitable product is FMC Wax 819. Use a 3% dilution of the wax. After dipping, place flower stems in water while the wax dries.

Storage Conditions: Anthuriums should be stored at 12.5 to 20 ºC (55 to 68 °F) because they are very sensitive to "chilling" injury (Pritchard et al., 1991). Holding the flowers for any length of time at temperatures below 10 ºC (50 °F) will induce purpling, then browning, and death of the flowers. Anthuriums should therefore never be pre-cooled with other flowers, nor held in low temperature cool-rooms. Anthuriums shipped in mixed loads at low temperatures should be protected from chilling exposure by appropriate insulation (for example wrapping the flowers in newsprint and packing them in an insulated box). Anthurium flowers can be stored for at least 1 week if packed in moist shredded newsprint and held at 15 ºC (59 °F). They also respond favorably to storage in controlled atmosphere. Vase-life after storage was increased by 50% when flowers were stored at 12.5 ºC (55 °F) in 2% O_2 for up to 2 weeks.

Packing: Anthuriums are commonly packed in moist shredded newsprint or other shredded paper. Major damage during transportation is the result of spadices puncturing the spathe of neighboring flowers in the pack. Many producers now sheathe the flowers in small plastic bags and pack the anthuriums more densely in the box.

Special Considerations: Anthuriums can have a vase-life of up to 3 weeks if properly treated. Even after storage, vase-life can be adequate if proper techniques are used to handle the flowers. They are very susceptible to stem blockage and easily bruised because of mechanically-induced injuries, especially during packing and unpacking. Keep holding solutions clean by using an effective preservative solution.

ASPARAGUS FERN, LACE FERN, SPRENGERI

Scientific Name and Introduction: *Asparagus spp.* Asparagus fern (*A. setaceus* and other species in the genus *Asparagus*) are probably better known in the floral trade as *A. plumosus* or plumosus fern, and provide an interesting foliage and filler for arrangements. These species are not true ferns but are members of the lily family, in the same genus as edible asparagus. *Asparagus densiflorus* "Sprengeri" group is another common filler foliage.

Quality Characteristics and Criteria: As with other foliage, asparagus fern should be harvested when the fronds are fully mature – immature tips a very likely to wilt after harvest. Make sure that the fronds are mature, uniform green, that there are no yellow leaves, and that leaves do not fall from the fronds when they are shaken.

Grading and Bunching: There are no formal grade standards for asparagus fern, but fronds should be

intact, or uniform length, maturity, and color. Fronds are frequently bunched in groups of 20, and not normally placed in sleeves.
Ethylene Sensitivity: Exposure to ethylene will cause leaf fall in some species of asparagus fern, and therefore pretreatment with 1-MCP or STS is beneficial.
Pretreatments: Because ethylene exposure will cause accelerated leaf fall, treatment with 1-MCP or STS is recommended.
Storage Conditions: Store asparagus ferns at 0 to 1 ºC (32 to 33.8 °F), wrapped in polyethylene to reduce drying out during storage. The fern should be cooled before being wrapped in polythene.
Packing: Because of their relatively low value, asparagus and other ferns are packed densely in boxes - usually horizontal boxes that are filled as full as possible. This places an additional emphasis on the importance of pre-cooling, but no paper or plastic is used, which permits reasonably effective forced air cooling.
Special Considerations: Asparagus fern suffers from premature leaf fall. Induced primarily by water stress, it can be a serious problem. To avoid yellowing and leaf fall, avoid prolonged storage. Certain preservative solutions aggravate premature leaf yellowing. However, preservative should be used in all arrangements containing this fern, as other items in the arrangement will benefit.

ASTER, MICHAELMAS DAISY
Scientific Name and Introduction: *Aster spp.* The family Asteraceae, and the genus *Aster* include numerous species and cultivars used in horticulture. *A. ericoides* 'Monte Casino' is particularly important in the florist trade. Another important aster for florists is the China aster, *Callistephus chinensis*.
Quality Characteristics and Criteria: As with most members of the Asteraceae, immature flowers (ones harvested too early) will generally not open properly. Purchase as you would purchase chrysanthemums, more open (at least 75% open) than in a bud stage. Avoid specimens with yellowing leaves as this is an indication of improper storage and/or growing conditions.
Grading and Bunching: There are no grade standards as such, apart from the standard quality attributes of stem length, foliage quality, uniformity, and freedom from defects. Depending on species and cultivar, bunches may be prepared by stem number (China aster, for example) or by bunch size ('Monte Casino' aster, for example).
Ethylene Sensitivity: Members of the Asteraceae are generally unaffected by exposure to moderate concentrations of ethylene.
Pretreatments: The vase-life of asters is often limited by poor water relations, demonstrated by wilting of the flower and/or buds. Their vase-life has been shown experimentally to be extended by a 10-sec pretreatment with a high concentration (1000 ppm) of silver nitrate, which is a very effective germicide.
Storage Conditions: Store asters at 0 to 1 ºC (32 to 33.8 °F).
Packing: Asters are packed in traditional flower boxes, hampers, or Proconas.
Special Considerations: It is very difficult to make broad flower care recommendations for asters because of the large number of species and cultivars. Keep stems and vase solution clean. It is especially important with asters to remove leaves that might be in the water since bacteria grow quickly on leaves that are under water, contaminating the vase solution and leading to early wilting. Treat with a hydrating solution and prepare the preservative solution properly to minimize contamination by debris and microorganisms.

BABY'S BREATH, GYPSOPHILA
Scientific Name and Introduction: *Gypsophila paniculata* A favorite for use in bouquets and dried flower arrangements, gypsophila is most often field grown. The flowers are sensitive to water deficit and intense sunlight, and will brown and shrivel easily if subjected to these stress conditions. On the other hand, damp or rainy conditions increase the risk of gray mold (*Botrytis*) and *Phytophthora* root rot. Gypsophila is Greek for 'gypsum-loving' in reference to this species' good growth performance in high calcium soils.

Quality Characteristics and Criteria: Gypsophila plants produce flowers on large panicles whose individual flowers open over a considerable time period. Flowering stems are usually cut 20 to 40 cm (8 to 16 in) long. The degree of maturity at harvest is determined by whether the flowers are intended for the fresh market or for dried arrangements. Stems are cut when 50% of the flowers are open if they are to be placed in a drying solution immediately or marketed within 24 h. Stems are cut when 20 to 30% of the flowers are open if they are to be dried later or held longer than 24 h. Purchase gypsophila that has plenty of unopened buds, shows no signs of water stress, wilting, or disease (brown florets).
Grading and Bunching: Stems are gathered into field bunches using rubber bands or ties to secure the cut ends. Bunches from California are sold as growers bunches with 5 to 25 stems whereas gypsophila from South America comes in bunches weighing 300 g.
Ethylene Sensitivity: Exposure to ethylene causes wilting of open flowers and sleepiness of opening buds.
Pretreatments: Gypsophila responds best to pretreatment with STS, which protects not only open florets but also the developing buds (Newman et al., 1998). Gypsophila flowers treated with STS and held in a solution containing Physan® will maintain excellent display life for several weeks, as new buds open on the panicle. However, STS sometimes is of little benefit because stem blockage prevents uptake. Be sure stems are rinsed and re-cut underwater before placement in STS.
Storage Conditions: Store at 0 to 1 ºC (32 to 33.8 °F) in high (90%) RH to reduce flower and stem desiccation. Because Botrytis can be a serious problem, florists should ask suppliers (or be prepared themselves) to treat with appropriate fungicides. Stems with about 50% of their flowers open can be kept in a preservative solution (200 ppm Physan) at 1 ºC (33.8 °F) for up to 3 weeks.
Packing: Gypsophila may be packed in horizontal boxes or hampers. Thirty bunches are packed in a standard box.
Special Considerations: Gypsophila harvested in the bud stage (5% of flowers open) can be opened to excellent quality in a bud-opening solution containing 200 ppm Physan-20 and 5 to 10% sucrose. Flowers should be held at about 20 ºC (68 °F), 50% RH, and with light levels of about 15 $mmol \cdot m^{-2} \cdot sec^{-1}$ PAR (use cool-white fluorescent lamps). For drying gypsophila, a solution containing 1 part glycerine to 2 parts water should be used. Cut stems are then dried by hanging bunches upside down in a warm dry environment.

BIRD OF PARADISE
Scientific Name and Introduction: *Strelitzia reginae* The bird of paradise inflorescence consists of a boat-shaped bract containing a series of 4 or 5 flowers, so when an exposed flower withers, another one can be pulled out. Few cut flowers have this capability. Traditionally, Southern California growers bag the inflorescence a few weeks before harvest. Slender, elongated waxed paper bags are placed over the expanding bracts a week or more before the orange flowers are ready to emerge. The bags protect the brittle flowers by holding them inside or next to the bracts. The bag also helps prevent Botrytis mold, rain and hail damage, aphid attacks, and sunburn of the flowers. The specific epithet reginae means “queen.”
Quality Characteristics and Criteria: Inflorescences bend as they reach maturity, assuming a 90º angle to the stem. The first emerging orange flowers can barely be seen through the paper bags. The stems are pulled at this point. Stems can also be harvested in the tight bud stage before the first flowers emerge. At this stage the inflorescence is swollen, and there is a slight orange crack on the upper surface. The inflorescence is mature at the tight bud stage and is at the optimum stage for harvest, from the point of view of ease of handling and flower longevity. Flower stems are generally pulled off rather than cut. A side to side pulling motion is often necessary to loosen the stem at the base of the plant, although the inflorescences can break off if jerked too vigorously. Make sure flower heads are dry at time of purchase. If flowers are wet or have excessive nectar exudation upon unpacking, then the possibility of subsequent disease problems is increased.
Grading and Bunching: Strelitzia stems are sorted into at least 3 grades according to stem length and inflorescence size. For premium grade flowers, the field bags are replaced with new bags. Five stems are

firmly tied together at 2 points with the inflorescences facing in the same direction. The stem ends are evenly trimmed. A paper wrapper is placed around the bunched inflorescences to further protect the flowers.

Ethylene Sensitivity: Strelitzia flowers are insensitive to ethylene and their life is not improved by treatment with STS or 1-MCP.

Pretreatments: Flower longevity can be substantially increased by pulsing buds or flowers for 24 h (48 h is even better) with a solution containing 10% sucrose, 250 ppm 8-hydroxyquinoline citrate (8-HQC), and 150 ppm citrate (Halevy et al., 1978).

Storage Conditions: The optimum long term storage temperature range for this species is 6 to 7 ºC (42.8 to 44.6 °F), which is different from most other flowers. Storage below this recommended range can result in chill disorders, the appearance of brown lesions on the flowers and bracts, and the failure of the flower to open properly. For short-term storage, hold the flowers at room temperature, or in a tropical storage room at 12.5 ºC (55 °F). Strelitzia flowers harvested in the tight bud stage will open and have satisfactory vase-life after 4 weeks in storage if pre-treated with a fungicide, wrapped to prevent desiccation, and stored at 7 ºC (44.6 °F) and 85 to 90% RH.

Packing: Waxed paper bags on each inflorescence and the paper wrapper on each bunch give ample protection from handling injury and desiccation. Because they are very heavy, Strelitzia stems should be packed in shallow cartons.

Special Considerations: If flowers do not emerge from the spathe (modified leaf below flower), the first flower can be gently eased out by hand and will normally provide good display life.

BOUVARDIA

Scientific Name and Introduction: *Bouvardia spp.* Bouvardia flowers are a relatively recent addition to the florist's palette. Their bright salmon, red, and white color range and interesting flower form offer interesting design possibilities. The genus is named after Charles Bouvard, 1572 to 1658, who was physician to Louis XIII and superintendent of the Royal Gardens in Paris.

Quality Characteristics and Criteria: Bouvardia flowers are normally harvested with two to three outer flowers open. Purchase when one or two flowers are open on each stem. Avoid flowers that have yellowed foliage, or are showing signs of wilting. If the flowers have been pretreated to prevent the effects of ethylene, there should be little shattering when the flower bunch is shaken.

Grading and Bunching: There are no formal grade standards for Bouvardia, but top quality flowers will be uniform in maturity and color, free of defects, and have good quality foliage and long stems. Flowers are normally bunched with 10 stems and sleeved prior to packing.

Ethylene Sensitivity: Accelerated wilting and abscission result from exposure of Bouvardia flowers to ethylene.

Pretreatments: Because of their ethylene sensitivity, Bouvardia flowers should be pre-treated with 1-MCP or STS. Research has shown STS to be the superior pre-treatment because it protects not only open flowers but also the developing buds from the effects of ethylene. Treatment for 4 to 24 h with water containing detergents such as Agral LN or Nonoxynol-8.5 prior to dry storage prevents early wilting of the flowers (van Doorn et al., 1993) .

Storage Conditions: Although previous recommendations have been to store Bouvardia at 7 to 10 ºC (44.6 to 50 °F), this species is not chilling sensitive, and therefore should be stored, like most temperate cut flowers, at 0 to 1 ºC (32 to 33.8 °F).

Packing: Bouvardia may be packed in horizontal boxes or Proconas.

Special Considerations: Bouvardia exhibits leaf yellowing and is wilt sensitive. In some markets a special preservative formulation is sold that can reduce leaf yellowing. Re-cut stems underwater and use good sanitation procedures to reduce the frequency of wilted flowers. Postharvest performance differs greatly among the many cultivars marketed.

CALLA LILY

Scientific Name and Introduction: *Zantedeschia spp.* The striking white blooms of *Zantedeschia aethiopica* have long been an important cut flower, and new green-tinged and different-shaped variants are increasingly important. The hybrid 'mini-callas,' with their elegant shape and wide range of colors, continue to increase in importance as cut flowers and potted plants. The showy 'spathe' is a leaf-like organ that surrounds the true flowers, the thick, fleshy 'spadix'. The genus is named for Francesco Zantedeschia who wrote about Italian plants around 1825. Although often called calla lilies, these flowers are not related to the true lily.
Quality Characteristics and Criteria: Callas should be harvested when the spathe has opened enough so that the spadix can be seen. Flowers harvested more mature will be more susceptible to damage, and may have reduced vase-life. The flowers are normally pulled from the rhizome, and re-cut to ensure adequate water uptake. The spadix (the thick fleshy inflorescence inside the showy spathe) should be visible at the time of purchase. Watch for bruising of the fleshy stems due to packaging. If cut too tight, flowers will usually not open properly.
Grading and Bunching: Quality callas have long stems, are uniform in maturity and color, and have no defects such as damage to the spathe or spadix. Both large and mini callas are normally bunched in groups of 10. Mini callas are sometimes sleeved to provide additional protection.
Ethylene Sensitivity: Calla flowers are not ethylene sensitive, although some researchers have shown positive effects of STS pre-treatment. Contrary to popular belief, callas do not produce significant quantities of ethylene.
Pretreatments: Callas do not require any pretreatments.
Storage Conditions: Callas should be stored at 0 to 1 ºC (32 to 33.8 °F).
Packing: The flowers may be packed horizontally or in upright hampers or water packs. If packed horizontally avoid direct contact with cleats, which may damage the fleshy stems. Standard callas may bend in response to gravity unless held at the proper storage temperature.
Special Considerations: The mini-callas have fewer postharvest problems and are generally easier to handle and use because of their smaller size.

CARNATION, MINIATURE CARNATION
Scientific Name and Introduction: *Dianthus caryophyllus* Long one of the most important of the commercial cut flowers, the carnation has benefited enormously from the use of STS, which can increase its vase-life two to threefold. The wide range of colors and forms, especially for miniatures, allows florists and consumers to use and enjoy them in many ways. The genus name, Dianthus, derives from the Greek for 'flower of love.' Carnations used to be called 'clove gilly-flowers' in reference to their intense clove-like aroma. Some modern cultivars are very fragrant and are used to make perfumes. Carnations can be stored longer than any other flower and can be opened to high quality flowers from very tight buds. Miniature carnations are also referred to as spray carnations.
Quality Characteristics and Criteria: The maturity at which carnations are harvested depends on the proposed marketing procedure. Star-stage buds are too immature for most purposes except long-term storage. Buds at the 'paint-brush' stage, with petals straight up, will open quickly. Flowers for immediate use are normally harvested with the outer petals between vertical and horizontal. To minimize spread of disease, avoid harvesting from plants with obvious disease symptoms. Many pickers place cut flowers on top of wires for later collection into bunches. Flowers collected into canvas slings can be taken to the shed by mechanical devices ranging from overhead cables to tractor-hauled trailers designed to hold slings. Standard carnations ship better and last longer if purchased in the bud stage, while miniature carnations should be purchased when at least one flower per stem is open. Fragrant cultivars have more consumer appeal.
Grading and Bunching: Both standard and miniature carnations are graded by stem strength, stem length, bloom diameter, and freedom from defects. Stem strength is determined by holding the stem horizontally at a point one inch above the minimum length for the grade. If the deviation of the flower head is more than 30° from horizontal (with the natural curvature down), the flower is considered

defective. Other defects include slabsides, bullheads, blown heads, singles, sleepy appearance, splits, discoloration, and damage from insects and diseases. Standard carnations are bunched, and tied at the base and at least one other place below the flower heads. Instead of different colored labels, some growers indicate different grades by color and/or number of rubber bands on the bunches. Standards for miniature carnation bunches vary; a bunch normally contains a minimum of 30 buds total, at least seven of which are open. With standard carnations, flower heads may be alternated (five high and five low) at the top of the bunch to produce a neat and compact bunch and reduce the risk of neck breakage.

Ethylene Sensitivity: Carnations are ethylene sensitive and exposure to ethylene causes premature petal wilting referred to as 'sleepiness.' Some newer cultivars are less sensitive to ethylene than the standard 'Sim' types, and carnations have now been genetically modified by the addition of a mutation of the ethylene binding site that makes them insensitive to ethylene (Bovy et al., 1999).

Pretreatments: Carnation flowers must be pre-treated with 1-MCP or STS. Research shows that the effectiveness of 1-MCP is lost within a week at room temperature, but is retained for extended periods when carnations are held at low temperatures. Pulsing the treated flowers overnight with a preservative containing 10% sucrose improves flower opening and quality carnation buds can be opened, at room temperature and under normal room lighting, in a solution containing 7% sucrose and 200 ppm Physan®. The buds should have been treated, first, with 1-MCP or STS.

Storage Conditions: Carnations should be stored at 0 to 1 ºC (32 to 33.8 °F). Bud-harvested flowers perform best in storage because they are less sensitive to ethylene than mature flowers. Flowers or buds for storage should be of the highest quality and absolutely free of pests and diseases. They should be treated with 1-MCP or STS and a fungicide for Botrytis control then packed in a box lined with polyethylene and newspaper. Open flowers can be stored 2 to 4 weeks, while bud-cut flowers can be safely stored up to 4 to 5 weeks. There are methods available for storing buds for up to 4 mo.

Packing: Carnations are usually packed in standard horizontal fiberboard boxes.

Special Considerations: Spray carnations do not always respond well to STS because the different flower maturities do not take up the STS solution equally. While it is difficult to recognize water-stressed carnations, severe reduction in vase-life is the result, so keep them hydrated when held above 0 to 1 ºC (32 to 33.8 °F).

CHRYSANTHEMUM, FLORIST MUM

Scientific Name and Introduction: *Dendranthema x grandiflorum* Less important than formerly, but still an important cut flower, chrysanthemums (which come in a wide range of colors and forms, including standard and spray, or pompon) have a long postharvest life when properly handled. The chief postharvest problems in these flowers are failure to draw water (which results in premature leaf wilting) and leaf yellowing. Chrysanthemum is Greek for "golden flower."

Quality Characteristics and Criteria: Standard chrysanthemums are normally harvested fully open, or nearly so, and pompons are harvested with the most mature flowers fully open. Harvesting too early may result in failure of the flowers to open. However, chysanthemums can be harvested as quite tight buds and opened satisfactorily with simple bud-opening solutions. Bud-cut standards can be harvested when the inflorescence is about 5 cm (2 in) across or greater and opened into full-sized flowers. Spray varieties can be harvested when most of the petals on the most mature flower are still upright. The flowers can be opened after storage or transportation. Stems should be cut (with a knife, shears) at least 10 cm (4 in) above the soil line to avoid taking woody plant tissue. Pinched spray chrysanthemums can be pulled from the soil and then cut to correct length. Leaves are removed from the lower third of the stems. Proper re-hydration is vital for good vase-life of chrysanthemums that have been stored or shipped long distances. Remove chrysanthemum bunches from the boxes, re-cut stems to remove about 2.5 cm (1 in) and place in a good re-hydration solution. Educate workers and customers to accept flowers that are from two thirds to three quarters open as these flowers will last longer than tighter harvested ones.

Grading and Bunching: Standard chrysanthemums are graded by length, and packed individually. Spray-types are graded by length and bunched. Standards or disbuds of equal sizes are graded into groups

of 10 or 12. Each bunch of five to eight spray chrysanthemums should be sleeved with plastic to prevent flowers from becoming entangled. Standards and spider mums can be wrapped individually with thin wax paper to avoid bruising and entangling florets. Some growers place nets over spider mums in the greenhouse before the buds open. .

Ethylene Sensitivity: Chrysanthemums are not sensitive to ethylene.

Pretreatments: Stems should be placed in a re-hydration solution, or water containing a germicide soon after harvest if they are not to be packed immediately (van Meeteren et al., 1999). Immersion in solutions of the cytokinin 6-benzyl adenine has been shown to be effective in preventing premature leaf yellowing in some spray cultivars that are prone to this problem. This treatment is not yet used commercially. Bud-harvested flowers can be opened in fresh-flower solutions containing 2 to 3% sugar (higher concentrations damage leaves) at 15 to 20 ºC (59 to 68 °F) with 16 h per day of normal room intensity light. Physan® is a common, effective germicide, but it discolors the stem portion in the solution; therefore only 3 to 8 cm (1.2 to 3.2 in) of solution should be used. After the buds are open, the injured portion of the stem can be removed. Silver nitrate at 25 ppm + citric acid at 75 ppm is very effective but more expensive to use than Physan. Silver nitrate is, however, absorbed into the stem and becomes a lasting germicide throughout the life of the flower. HQC at 200 ppm has

Storage Conditions: Chrysanthemums should normally be stored at 0 to 1 ºC (32 to 33.8 °F). Bud-cut standard chrysanthemums harvested when the bud is 1.2 cm (3 in) across can be stored up to 2 weeks and 1.6 cm (4 in) buds for up to 3 weeks at 0 to 1 ºC (32 to 33.8 °F). Bud-cut stems that are held in cold storage beyond the recommended time can develop flat-topped flowers. Fully mature blooms can be stored dry (wrapped in polyethylene) for 3 to 4 weeks at 0 ºC (32 °F). Storage at 0 to 1 ºC (32 to 33.8 °F) should not exceed 2 weeks. Yellowing of leaves can occur at 5 ºC (41 °F) in the dark, but is less likely to occur at 1 ºC (33.8 °F).

Packing: Chrysanthemums are normally packed in standard horizontal fiberboard boxes. Standards are packed individually, and a layer of wax paper often separates each row of flowers.

Special Considerations: The main postharvest problems for chrysanthemums are premature foliage yellowing, wilting and the failure of the flowers to fully open. Yellow foliage is cultivar specific and is caused by poor production, excessive or improper storage and preservative solutions used at higher than recommended concentrations. The bottom portion of some mum stems can be woody: make sure these stems are cut above this woody tissue in order to facilitate water uptake, delay wilting and extend end-user life.

DAFFODIL

Scientific Name and Introduction: *Narcissus cvs.* Daffodils, symbols of Spring and known for their bright yellow, orange, red, pink, and white colors, are garden favorites world-wide. Unfortunately, these flowers have relatively short vase lives that cannot as yet be increased substantially with standard postharvest treatments. Narcissus is a classical Latin name, from the Greek; perhaps as the origin suggests, an allusion to narcotic properties. It is not clear whether it was named after the youth Narcissus in mythology.

Quality Characteristics and Criteria: Daffodils are normally harvested at the "goose-neck" stage. Jonquils are often harvested at the "one bell" stage, when only one flower is open on the spike. Harvesting is normally done by cutting the flower from the foliage and bulb, although the whole plant may be removed and the bulb and leaves then cut from the flower spike. Flowers should be purchased in the pencil to gooseneck stages. These terms refer to flower position relative to the stem; pencil being straight up and gooseneck bent downwards to about a 45° angle.

Grading and Bunching: As with a number of other "spike"-type flowers, narcissus will bend upwards away from gravity if laid down flat. For this reason flowers should be kept vertical when they are not cooled to the proper storage temperature. Although there are no formal grade standards for these flowers, the most important quality attributes are maturity, uniformity of color, and freedom from damage or disease. Flowers are normally bunched in groups of 10 or 25, tied with twistems and sleeved in paper or

plastic.
Ethylene Sensitivity: Senescence of these flowers is accelerated by exposure to ethylene, although their natural senescence does not involve ethylene. Pretreatment with 1-MCP or STS may extend flower life where flowers are handled in ethylene-polluted environments such as mass market outlets.
Pretreatments: Pretreatment with 1-MCP or STS can help extend vase-life of flowers that are likely to be exposed to ethylene.
Storage Conditions: Store daffodils and jonquils at 0 to 1 ºC (32 to 33.8 °F). Store upright as these flowers will bend upwards from gravity. Narcissus can be stored at 1 ºC (33.8 °F) and 90% RH for up to 2 weeks with only slight reduction in vase-life. They may also be stored for several weeks in an atmosphere of 100% N_2. Narcissus stored in this way have as long a vase-life as fresh cut flowers and nearly double the vase-life of air-stored flowers. Flowers are best stored upright and dry, in containers that permit rapid cooling of the flowers, eg., in fiberboard boxes.
Packing: Because of their sensitivity to gravity, daffodils are often packed in hampers, although they may be packed in horizontal fiberboard boxes if they are properly pre-cooled and maintained at the correct storage temperature.
Special Considerations: Daffodils exude a gelatinous (slimy) substance that, when transferred through a common holding solution to other flowers like tulips and anemone, can result in premature death for the other species (van Doorn, 1998). Therefore, place freshly cut or re-cut flowers into a separate holding bucket for a few hours. Later they can be placed with other flowers and used (even re-cut if required) in arrangements without affecting the life of the other flowers.

DELPHINIUM, LARKSPUR
Scientific Name and Introduction: *Delphinium, Consolida spp.* The tall spikes of delphinium and the smaller spikes of larkspur are important accent flowers, with colors ranging from white through pink, purple and blue.
Quality Characteristics and Criteria: Delphiniums and larkspur are normally harvested with one to two open flowers on the spike. Avoid flowers with mildew-infected leaves. At least one to two flowers per stem should be fully opened at the time of purchase with no sign of flower fall. Make sure stems are rinsed prior to re-cutting and arranging, so as to remove dirt and debris.
Grading and Bunching: There are no formal grade standards for larkspur and delphinium. Flower number per spike, stem length, stem straightness, and foliage quality are important quality attributes in these flowers. Larkspur are normally bunched by size with an average of 10 stems per bunch.
Ethylene Sensitivity: Delphiniums are very sensitive to ethylene, which causes rapid loss of all the flowers on the spike.
Pretreatments: Flower spikes should be pretreated with 1-MCP or STS to extend their vase-life and protect them from exposure to ethylene. Because flowers are on spikes and are therefore at different maturity stages at the time of anti-ethylene treatment, STS may be a more effective anti-ethylene treatment than 1-MCP.
Storage Conditions: Delphinium and larkspur should be stored at 0 to 1 ºC (32 to 33.8 °F). For longer term storage, they should be wrapped in perforated polyethylene to reduce water loss.
Packing: These flowers are often packed in hampers with or without water, but may also be packed in standard horizontal boxes. They are somewhat sensitive to gravity, so horizontally-packed flowers should be pre-cooled and maintained at proper holding temperatures.
Special Considerations: Flowers called larkspur or delphinium often are named incorrectly.

EMERALD PALM
Scientific Name and Introduction: *Chamaedorea spp.* Chamaedorea is a small-leaved member of the palm family with leaves that perform well in the vase. Three other members of the palm family (coconut, date-palm, and oil-palm) make up the commercially important species for food consumption in North America.

Quality Characteristics and Criteria: Chamaedorea palms are harvested in the wild as well as being produced in plantations. Fronds are harvested when fully expanded, mature, and dark green. Fronds of Chamaedorea should be dark green, clean, and uniform. Avoid fronds whose leaf tips showing marginal necrosis or dead areas and fronds that are beginning to turn yellow.
Grading and Bunching: There are no formal grade standards for Chamaedorea, but uniformity, size, color, and absence of defects are important criteria of quality. Bunches of Emerald palm contain 25 stems.

Ethylene Sensitivity: Exposure to ethylene has no deleterious effects on Chamaedorea fronds.
Pretreatments: No pretreatments are recommended for Chamaedorea fronds.
Storage Conditions: Because Chamaedorea is a tropical foliage, it is sensitive to chilling damage if stored at low temperatures for extended periods. Fronds may be stored for 1 to 2 weeks at 12.5 ºC (55 °F) and high RH.
Packing: Fronds are packed densely, usually without sleeves of paper, in standard horizontal fiberboard boxes.
Special Considerations: Early death of the fronds, drying, and inrolling of the individual leaves (pinnae) is the result of water stress. So, make sure stems are re-cut before arranging them as this can quadruple their life. The species is chill sensitive, so hold at proper temperatures.

EUCALYPTUS, SILVER DOLLAR TREE
Scientific Name and Introduction: *Eucalyptus spp.* The silvery-green leaves of the juvenile form of Eucalyptus pulverulenta are a very popular foliage item, used in fresh and dried form. A number of other species of Eucalyptus also are used as cut foliage. Eucalyptus is Greek for well and lid, referring to the sepals and petals, which are united to form a cap that is shed when the flower opens, revealing the showy colored stamens.
Quality Characteristics and Criteria: As with other foliage, Eucalyptus performs better in the vase if leaves are mature. Branches are harvested to provide long stems, but leaving growing points behind for development of new branches. Stem tips should not be wilted when purchased.
Grading and Bunching: Quality foliage is bright blue-green in color, has undamaged leaves, and is uniform in length. Eucalyptus branches are sold in grower bunches by weight, usually as 454 g (1 lb) bunches.
Ethylene Sensitivity: Eucalyptus branches are not sensitive to ethylene, but if the foliage is poorly handled, is warm, and water-stressed, it can produce concentrations of ethylene that could damage ethylene-sensitive flowers that have not been treated with 1-MCP or STS.
Pretreatments: No pretreatments are required.
Storage Conditions: Eucalyptus foliage should be stored at 0 to 1 ºC (32 to 33.8 °F).
Packing: Eucalyptus is normally packed in horizontal fiberboard boxes without additional packing materials.
Special Considerations: Handle this species with gloves to prevent hands from becoming sticky. Eucalyptus are native to areas like Australia and Tasmania but over 200 species have been introduced elsewhere. As a result, this species predominates in certain woodlands in California. Many florists believe eucalyptus gives off a lot of ethylene because of its strong fragrance. In fact, most species and cultivars do not produce excessive amounts of ethylene gas, although some will produce potentially detrimental quantities of ethylene if they become water stressed. Hence, make sure this species is properly hydrated. Eucalyptus can be treated with various colored glycerin-based solutions, which result in preserved specimens. Australian and Israeli researchers are investigating the possible use of Eucalyptus as flowering branches, and we may expect to see this interesting item increasing in the trade in the future.

FIR, SPRUCE, PINE
Scientific Name and Introduction: *Abies, Picea, and Pinus, spp.* Fir, spruce and pine are all members of the pine family (Pinaceae). The 200+ species are noted for producing resins, lumber and numerous

ornamental landscape species. As foliage, mature branches are long-lasting, provide a piney fragrance, and are often used in arrangements during the Christmas season.
Quality Characteristics and Criteria: Branches should be harvested when tips and needles are mature. Soft green growth is more likely to wilt in the vase. Branches should be mature, with uniform dark green foliage. Avoid bunches with fungal growth and whose needles are falling off.
Grading and Bunching: There are no grade standards for conifer branches and Christmas greens. Quality foliage is dark green, well hydrated and shows no abscission or fungal infection.
Ethylene Sensitivity: Conifer branches are not usually affected by exposure to ethylene, and contrary to what is commonly suggested, do not produce any ethylene.
Pretreatments: No pretreatments are required for conifer branches.
Storage Conditions: Store at 0 to 1 ºC (32 to 33.8 °F). These foliages store very well when held around 0 °C (32 °F), wrapped in plastic to reduce water loss. Make sure the branches are cooled prior to wrapping in plastic to avoid condensation and rots.
Packing: Because of the low value and relative hardiness of these materials they are usually packed loose in horizontal fiberboard boxes without any protection.
Special Considerations: Anti-transpirant dips have not been shown to reduce water stress nor to extend user life. Despite their strong aroma, these foliage materials have not been demonstrated to produce ethylene. If they are infected by fungi, it is possible that they may produce ethylene, but otherwise they are safe to store with ethylene-sensitive flowers.

FREESIA
Scientific Name and Introduction: *Freesia x cvs.* Native to South Africa, the single or double flowers range in colors from yellow, orange, red, bronze, to purple. Some cultivars retain the delightful fragrances that are common in garden freesias. The genus was named for Dr. Freese (1785 to 1876), a native of Kiel, Germany and a student of South African plants.
Quality Characteristics and Criteria: Stems are harvested when the first flower colors and opens. Several flowering stems may be harvested from one plant. In that case, the uppermost flower stem should be cut just above the junction of the desired lateral flowering stem. When the lateral stem reaches maturity, it too is harvested. The upper flowering stem will have more flowers per stem and better postharvest life than lateral flowering stems. One or two florets per stem should be just beginning to open at the time of harvest and hence, at the time of purchase. If harvested too tight, many florets may not open unless preservative solutions are used properly. Learn cultivar names and market those that have good postharvest characteristics.
Grading and Bunching: There are no standard grades for freesias, but they may be graded according to maturity, number of flowers per stem and the length of stem. Quality freesias have at least seven florets per spike, and have long straight stems. Flowers are sold in bunches of 10 stems, usually of the same color.
Ethylene Sensitivity: The open florets on freesia inflorescences are not affected by exposure to ethylene, but the effects of this gas are seen in young buds, which fail to develop.
Pretreatments: Pre-treatment with 1-MCP or STS pulse pre-treatment is effective in preventing abortion of small buds on the inflorescence. Freesias can be pulsed for 18 h in the dark with a preservative solution containing 25% sucrose. Pulsing should be carried out at about 20 ºC (68 °F) with 85% RH. This treatment will increase flower size, percentage of flowers that open, and vase-life (van Meeteren et al., 1995).
Storage Conditions: Freesia should be stored at 0 to 1 ºC (32 to 33.8 °F).
Packing: Freesias are packed in horizontal boxes or upright hampers.
Special Considerations: The species is ethylene sensitive, but it responds well to STS, which inhibits premature flower fading and the appearance of translucent petals. STS helps open more flowers per stem and more open flowers absorb more STS, protecting against ethylene-induced disorders. Water stress can cause significant ethylene production and reduce life.

GERBERA, TRANSVAAL DAISY

Scientific Name and Introduction: *Gerbera jamesonii and hybrids* Cut gerbera flowers, known for their remarkable variety in coloration and form, are an increasingly important part of the florists' palette. Their postharvest life can be substantial if they are given proper postharvest conditions, but they are sensitive to gravity, to light, and to bacterial contamination of the vase solution. Originally spelled "Gerberia," the genus was named after Traug Gerber, a German naturalist.

Quality Characteristics and Criteria: Most gerbera varieties should be harvested when the two outer rows of disk florets have begun to open, but some cultivars can be harvested later, particularly those types that close at night. Flowers are harvested by twisting the stems off near the point of attachment to the rhizome; this is thought to encourage subsequent flower production. If flower stems are pulled from the ground, immediately cut 10 cm (4 in) from the bottom to remove the 'woody' base of the stem, which does not draw water readily. Place soon after harvest in a solution containing 40 ppm hypochlorite. Make sure that at least one or two rows of disk flowers (tubular flowers in the center of the head) are showing pollen. If stems were pulled from the ground, cut 10 cm (4 in) off the bottom to remove the woody portion and improve water uptake. With well over 300 cultivars in commerce that vary greatly in vase-life (Wernett et al., 1996), it is important that florists order gerberas by cultivar name. Unfortunately, the large number of cultivars makes it difficult to learn the names of better cultivars.

Grading and Bunching: Maturity, freedom from defects, and stem length, strength and straightness are important quality criteria for gerberas. Some producers bunch the flowers, but most pack them individually. Some producers place each flower into a firm plastic sleeve, and may insert the stem into a plastic tube to reduce stem bending.

Ethylene Sensitivity: Gerberas are unaffected by exposure to ethylene.

Pretreatments: Present industry practice is to place cut gerbera stems in a 40 ppm sodium hypochlorite solution immediately after harvest to improve vase-life. A rapid pulse treatment with 100 ppm silver nitrate is sufficient to greatly alleviate postharvest problems with gerbera cultivars that are relatively short-lived. The silver nitrate presumably guards against bacterial contamination of the stem and vase water. After the dip, rinse the flowers in good quality water. This treatment causes only minimum phytotoxicity (brown damage to the stem). The use of 6% sugar + 200 ppm 8-HQC as a preservative has shown to be of some benefit but can cause stem elongation during storage and may reduce overall flower quality.

Storage Conditions: Gerberas should be stored at 0 to 1 ºC (32 to 33.8 °F); the widely-held opinion that gerberas are sensitive to chilling injury has not been scientifically substantiated. Generally, gerberas should not be stored longer than 1 week; even this short storage period can reduce subsequent vase-life.

Packing: Most commonly, producers pack individual flowers horizontally in shallow cardboard containers especially designed to support gerberas. Flower stems are passed through slits in the bottom of a cardboard tray so that the flower heads face up showing their colors while the stems pass under the box. Several rows of flowers can be arranged in each box. The boxes are then hung so that the stems dangle downward and can be placed in a re-hydration solution (hypochlorite is most commonly used). Afterward, two trays of flowers are packed horizontally into a fiberboard box in such a way that the flowers are facing upward and easily seen, while the stems are underneath the flower cards.

Special Considerations: Stem bending is primarily in response to gravity, and is greatly reduced if flowers are held at the proper storage temperature. One of the major problems in postharvest handling of these flowers is their tendency to 'conk,' which is folding of the stem 10 to 15 cm (4 to 6 in) below the flower head, resulting in an unmarketable flower. This bending has been variously attributed to harvesting of the flower before the stem has hardened sufficiently, and/or microbial plugging of the stem and subsequent water stress. The tendency to conk varies with variety and also varies throughout the year for any given variety. Be sure to enhance water uptake by keeping holding solutions and buckets clean and including hypochlorite in the water. Since more water is lost through the flower stem (scape) than through the flower petals, the scapes should be handled with as much care as the flowers themselves. Hang flower

heads through a meshed support or shipping tray when first hydrating to keep stems straight.

GINGER, SHELL GINGER, TORCH GINGER

Scientific Name and Introduction: *Alpinia zerumbet, Alpinia purpurata.* The ginger flowers represent a range of species and genera from the tropics that include the plants producing the edible ginger rhizome. One of the common lei flowers used in Hawaii is white-ginger. Torch ginger flowers are spectacular spikes of red flowers that give an especially tropical impact in arrangements. The genus is named after the Italian botanist Prosper Alpinus.

Quality Characteristics and Criteria: No specific maturity standards have been developed for these flowers. They are normally harvested when all flowers on the spike are open. Make sure flowers do not exhibit chill damage symptoms such as off-colored (grayish/bluish) blooms.

Grading and Bunching: There are no specific grade standards for gingers. Proper maturity and freedom from flower and foliage defects would be important indicators of quality. Gingers are large flowers and are therefore normally packed individually. Some species may be individually sleeved to protect the delicate petals.

Ethylene Sensitivity: These flowers do not appear to be particularly sensitive to ethylene.

Pretreatments: There is no evidence that pre-treatments provide any benefit to ginger flowers.

Storage Conditions: Store at 12.5 to 15 ºC (55 to 59 °F). Gingers are chilling sensitive, so they must be held at warmer temperatures.

Packing: Gingers are packed flat in standard or insulated fiberboard boxes.

Special Considerations: Their large size makes them difficult to manage. Since insects sometimes make the trip from grower, wholesaler to retailer, make sure flowers are inspected and any insects removed.

GLADIOLUS, GLAD

Scientific Name and Introduction: *Gladiolus cvs.,* hybrids. Still an important commercial cut flower despite a substantial decline in production in recent years, gladiolus responds well to proper postharvest management. The smaller-flowered and 'butterfly' cultivars, as well as modern standards in a variety of colors and forms have helped transform this often stereotypic funeral flower into a contemporary favorite that can be an important accent flower in arrangements. *Gladiolus* is Latin for small sword, in reference to the sword-shaped leaves. Modern day gladioli are the results of hybridization programs, using South African species that commenced in Belgium around 1841.

Quality Characteristics and Criteria: Normal harvest is at the stage when the bottom two or three florets on the spike are showing color. For long-distance transportation, an even earlier harvest stage can be recommended if it is combined with sugar pulsing to ensure proper opening of the flowers at their destination. Local market flowers are cut when the first floret is open. Harvesting is carried out so as to leave as many leaves on the plant as possible. A knife is run down between the leaves with the back of the knife down. When the knife blade is as low as the cutter believes it should go, it is pulled upward and out, severing the stem, which can then be pulled out of the leaves. It is possible to open almost all florets on flower spikes if they are harvested in the green bud stage and handled properly. However, it is recommended that color be visible in one to three florets at time of purchase to help ensure that most florets will open.

Grading and Bunching: Gladioli, like most spike-type flowers, are very sensitive to the force of gravity, and will always tend to grow away from the ground, particularly at warm temperatures. This can result in permanent deformation of the upper part of the spike, and consequent reduction of flower quality. Throughout the postharvest procedures, gladioli should be held upright to avoid this effect. This rule may be relaxed only while the flowers are held at low temperature during storage and transportation. Quality factors for gladiolus include stem straightness and strength, freedom from damage and disease, and maturity. The flowers are bunched by color and maturity in groups of 10.

Ethylene Sensitivity: Although exposure to ethylene does not affect the life of open florets, it can reduce the flower life by causing abortion of unopened buds (Serek et al., 1995).

Pretreatments: Gladioli respond very well to pulsing with a preservative containing 20% sugar (sucrose or glucose). Pulse overnight at room temperature or in the cooler. The flowers can be pulsed in the dark. Treatment with 1-MCP or STS provides some protection against the effects of exposure to ethylene, which causes young buds to abort.
Storage Conditions: Although earlier recommendations were to store gladiolus at 5 ºC (41 °F) to prevent chill damage to tips, our research has shown that they can safely be stored for a week at 0 to 1 ºC (32 to 33.8 °F). Flowers are negatively geotropic (they bend away from the force of gravity), so they are commonly stored and shipped upright. One beneficial aspect of low temperature handling and transportation is that this negative geotropic response is inhibited, allowing gladioli to be packed in the standard horizontal flower box. For longer storage, gladioli are best stored upright at the lowest safe storage temperature.
Packing: Traditionally packed in tall 'glad hampers' clearly marked for upright stacking. Since the advent of pre-cooling, some shippers have packed gladiolus in normal flower boxes. This practice is fairly safe if the flowers will remain refrigerated throughout the marketing chain, and will be removed from the box on arrival. Excessive moisture on the foliage should be avoided so as to minimize the risk of Botrytis infection.
Special Considerations: Some cultivars are sensitive to fluoride which can result in deterioration of the petal margin (bleaching, water soaking, then necrosis), failure of florets to open and develop normally, burning of the floret sheath, and marginal leaf scorch.

HELICONIA, PARROT FLOWER
Scientific Name and Introduction: *Heliconia humilis, Heliconia psittacorum* The varied and fantastic forms and rich colors of the different species of Heliconia make them an important florist item, particularly prized for large and signature arrangements. Heliconia is named after Mount Helicon, the seat of the Muses, the nine goddesses of the arts and sciences in Greek mythology. Like their god Apollo, the Muses supposedly remained young and beautiful forever like the long-lasting and elegant flowers of Heliconia. Lobster claw and Crab's claw are additional common names for flowers in this genus.
Quality Characteristics and Criteria: Heliconia are normally harvested fully mature - the flowers will not open past the stage at which they are harvested. While flowers last longer if the bracts are less open compared to more open, they generally do not open further after harvest and that may reduce their visual appeal. Therefore, the openness of the flower at purchase often is the most it ever will open. Consumer life varies greatly among species and cultivars, thus, learn species and cultivar differences.
Grading and Bunching: Quality flowers of Heliconia are fully mature, free of defects (damage or discoloration) on the flowers, and have good quality foliage (when present). Both the smaller, hanging species and the larger, more upright species are packed individually by stem.
Ethylene Sensitivity: There is no evidence of any deleterious effects of ethylene exposure on the vase-life of Heliconias.
Pretreatments: No pretreatments have proved beneficial for Heliconias. Some species may benefit from the flowers being dipped in an anti-transpirant, such as those sold in garden centers for use on woody plants. However, no anti-transpirant product is presently sold for this use.
Storage Conditions: Heliconias are native to the tropical Americas, and are therefore very sensitive to chilling injury. They should never be held at temperatures below 10 to 12.5 ºC (50 to 55 °F). Flowers may be stored in moist shredded newsprint, or in water at 12.5 ºC (55 °F).
Packing: Heliconias are normally packed in horizontal fiberboard boxes.
Special Considerations: Heliconias most often die early due to poor water uptake. They can last for up to 2 weeks in plain tap water if the water is free of microorganisms. Larger diameter and longer stemmed specimens last longer. Since insects sometimes make the trip from grower to retailer, make sure flowers are inspected and any insects removed.

HOLLY, ILEX

Scientific Name and Introduction: *Ilex spp.* Evergreen shrubs, hedges and small trees prized for their holiday-season dark green leaves and bright red fruits. The plants carry female and male flowers on separate trees, and are therefore termed 'dioecious'. Thus, only female plants are harvested for specimens possessing fruit.
Quality Characteristics and Criteria: Holly is harvested when the fruits are already fully red. Avoid purchasing holly in packages when condensation is visible. This indicates poor temperature management and possible fungal growth and ethylene production. Also, avoid those where berry or leaf fall has occurred.
Grading and Bunching: Quality holly branches have uniform dark green leaves, are free of blemishes, and have bright red berries. They are seldom gathered into bunches, but may be grouped and placed in polyethylene bags.
Ethylene Sensitivity: Exposure to ethylene results in loss of berries and leaves, and is a common problem in holly handled through mass market outlets.
Pretreatments: Because of its ethylene sensitivity, holly should be pretreated with STS or 1-MCP, which prevents bud and leaf loss during marketing (Joyce et al., 1990).
Storage Conditions: Holly should be stored at 0 to 1 ºC (32 to 33.8 °F), and may even be held for longer periods at lower but non-freezing temperatures.
Packing: Holly may be packed in hampers or horizontal boxes. In the past, the branches were treated with various solutions (containing naphthalene acetic acid, NAA) to reduce their sensitivity to ethylene, and were therefore sometimes packed (wet) in wax-treated cartons. The use of 1-MCP should greatly simplify the marketing of this product.
Special Considerations: There are major differences among holly types in their sensitivity to ethylene. For example, 'Burford' is essentially insensitive to ethylene, while Chinese and English types are very sensitive. Therefore, know the type of holly being marketed. Some producers will dip holly into various solutions in an attempt to reduce fruit and leaf fall and/or package the product in such a way as to extend life. However, at wholesale or retail levels there is not presently a product to retard fruit loss, other than STS. Treating with STS does reduce fruit and leaf fall. Do not pre-green arrangements with holly, as it will not last.

HUCKLEBERRY
Scientific Name and Introduction: *Vaccinium ovatum* Huckleberry is native to the Western coast in areas from northern California to British Columbia. Vaccinium is the ancient Latin name for blueberry, and the specific epithet 'ovatum' refers to the oval leaf shape of this species.
Quality Characteristics and Criteria: Harvest branches when fully mature, without soft tips. This species is very long lasting with few postharvest problems. Thus, if it looks good at time of purchase it should perform well.
Grading and Bunching: N/A.
Ethylene Sensitivity: Huckelberry is not sensitive to ethylene.
Pretreatments: No pretreatments are required for huckleberry.
Storage Conditions: Huckleberry can be stored for extended periods by enclosing pre-cooled bunches in a plastic vapor barrier and holding them near 0 ºC (32 °F).
Special Considerations: Watch for excessive storage as depicted by fungal growth (fuzziness), and watersoaked or discolored leaves. Their woody stems sometimes make it difficult to re-cut. Re-cutting this species is less critical than for other floral crops.

IRIS, FLEUR-DE-LIS
Scientific Name and Introduction: *Iris cvs., hybrids* Because of their intense yellow, blue, and purple colors, and the elegant shape of their flowers and foliage, bulbous (Dutch) Iris are in considerable demand as cut flowers. Unfortunately, they are also one of the shortest-lived of the commercial cut flowers, and may not even open if handled improperly or held too long before sale. In recent years, other iris species,

eg., the ‘flag’ or German iris, which have even shorter vase-life, have been used in the trade. Iris is Greek for ‘rainbow’ in reference to the range of flower colors.
Quality Characteristics and Criteria: Iris grown at low temperature should be harvested more open than those grown in warmer conditions. Iris flowers are normally harvested at the "pencil stage," when a line of color projects out of the sheathing leaves. The 'Blue Ribbon' cultivar should be harvested more mature, when the edge of one petal is unfurled. Iris are pulled from the field at the correct stage of maturity. The bulb is cut off and the lower foliage removed. The flower stems are then placed in water. Wholesale and retail florists should purchase iris in the pencil stage. This term describes flowers that exhibit a line of color vertically, as the sheathing leaves covering them unfurls, but before the flower petals reflex. A major exception is the cultivar ‘Blue Ribbon,’ which should be more open at the time of purchase.
Grading and Bunching: There are no formal grade standards for iris flowers. Flowers should be uniform in variety, color, and maturity. Foliage should be relatively undamaged and free from disease. Stems should be strong and straight. Flowers are normally bunched in groups of 10, and the bunches are tied with rubber bands or twistems.
Ethylene Sensitivity: Iris are not affected by exposure to ethylene.
Pretreatments: There are no recommended pretreatments for iris flowers.
Storage Conditions: Store iris dry, upright, at 0 ºC (32 °F) for no more than 1 week. Some growers store iris with the bulb attached. Prolonged storage may result in failure of flowers to open (especially the 'Blue Ribbon' cultivar). Storage at warmer temperatures will result in ‘popping’ of the flower when it is re-hydrated.
Packing: Iris are normally packed in upright hampers.
Special Considerations: Some increase in vase-life has been realized by including a high concentration of benzyladenine in the vase solution, and pretreatments with gibberellins have been shown to overcome the negative effects of dry storage (Celikel and van Doorn, 1995b).

LEATHERLEAF FERN
Scientific Name and Introduction: *Rumohra adiantiformis.* By far the most popular cut foliage for use in arrangements, with year-round availability and good display life. Leatherleaf fern is grown in shade-houses under sub-tropical conditions. The specific epithet adiantiformis indicates the similarity to the fronds of Adiantum, the maidenhair fern. The Greek "adianton" means unwettable - a reference to the fact that fern fronds shed water. It is probably the most commonly used floral green.
Quality Characteristics and Criteria: Avoid wilted or yellow fronds.
Grading and Bunching: N/A
Ethylene Sensitivity: No
Pretreatments: N/A
Storage Conditions: 1 to 6 ºC (33.8 to 42.8 °F)
Packing: N/A
Special Considerations: Frond curl or postharvest wilt is a disorder that occurs more frequently from July to November. The precise cause of this disorder is not known and it cannot be prevented at grower, wholesale, or retail levels. Water stress can make the frond curl worse; however, leatherleaf is very tolerant to water stress conditions when frond curl is not a problem. The use of some postharvest anti-transpirant (wax-type) dips can enhance vase-life but does not reduce frond curl. Dipping leatherleaf in plain tap water can reduce vase-life. The brown bumps (sori or fruit-dots found on the back of some leaves (fronds) has not been reported to reduce life.

LEMONLEAF, SALAL
Scientific Name and Introduction: *Gaultheria shallon* A hardy, long-lived cut foliage, salal was named for Dr. Gaultier, a physician from Quebec in about 1750.
Quality Characteristics and Criteria: Branches should be harvested when the leaves are mature,

without tender young growth at the tips. Salal is very long lasting and has few postharvest problems. If foliage is of good quality at time of purchase, it should provide satisfaction in the vase.
Grading and Bunching: Quality foliage has uniform mature green leaves with no damage, defects, or disease. Salal is usually sold 20 stems per bunch.
Ethylene Sensitivity: Salal is not affected by exposure to ethylene.
Pretreatments: Salal does not require any pretreatments to perform satisfactorily in the vase.
Storage Conditions: Salal should be stored at -0.5 to 1 ºC (31.1 to 33.8 °F). Once harvested, bunched and cooled, lemonleaf is normally stored at or slightly below freezing, in large bins lined with plastic to reduce water loss.
Packing: Salal is normally packed in horizontal fiberboard boxes.
Special Considerations: Even though the stems are woody, salal is adapted to standard florists' procedures for re-hydration and use in arrangements.

LIATRIS, GAY FEATHER
Scientific Name and Introduction: *Liatris pycnostachya, L. spicata* The specific epithet pycnostachya means thick-spiked in reference to flowers while spicata means spike. L. spicata is taller of the two species. Native to prairies of North America, liatris was developed as a cut flower in Israel. The bright purple spikes provide interesting texture and line in arrangements, and can open fully if properly treated after harvest.
Quality Characteristics and Criteria: Liatris spikes should be harvested with no more than 25% to 33%) of the flowers in the spike open. They may be harvested with only the top buds showing color and will open fully if provided with an effective preservative. Liatris responds best when about one-quarter to one-third of the flowers are open. However, if preservative solution is properly used, flowers can be harvested with no color showing and subsequently opened.
Grading and Bunching: Quality Liatris flowers are of proper maturity (no more than one third of the flowers on the spike open), are free from defects and damage, and have good quality foliage. They are normally bunched in groups of ten and sometimes sleeved.
Ethylene Sensitivity: Liatris flowers are not affected by exposure to ethylene.
Pretreatments: Pulsing with preservative containing additional sugar (10 to 20%; about 100 g of sugar per quart or liter of water) will improve opening of tight-cut flowers (Han, 1992).
Storage Conditions: Store Liatris at 0 to 1 ºC (32 to 33.8 °F).
Packing: Liatris are normally packed in horizontal fiberboard boxes, but may also be packed in hampers.

Special Considerations: Be careful of fungal problems such as Botrytis (especially for those grown outdoors) as well as water stress. Leaf yellowing and reduced life are common when these problems exist and are not easily controlled. Using preservative solution helps open more flowers per stem, but doesn't make individual flowers last longer. A member of the Asteraceae (chrysanthemum or aster family), this species is also unusual in that flowers open from the top of the stem downwards; delphinium, gladiolus, snapdragon, and most other spiked-type flowers open from the bottom up.

LILY OF THE NILE, AGAPANTHUS
Scientific Name and Introduction: *Agapanthus africanus* Agapanthus is Greek for "love flower." The globose heads of Agapanthus are a pleasing accent for Spring and early-Summer arrangements, providing an alternative source of blue. The most common flower color is blue, but white cultivars are also available. Miniature, dark blue ('Storm Cloud') and reduced-shatter cultivars have been developed.
Quality Characteristics and Criteria: Agapanthus flowers are normally harvested when the bud bract has fallen off and no more than three florets are open. Stalks are cut near their base with a sharp knife. Ensure that flowers are of proper maturity. If the neck of flowers is bent upward, they have been transported at warm temperatures and have responded to gravity.
Grading and Bunching: No formal grade standards have been established. Agapanthus flowers are

bunched in groups of 5 or 10 stems.
Ethylene Sensitivity: Ethylene exposure results in loss of florets from Agapanthus.
Pretreatments: The vase-life of freshly-cut Agapanthus flowers was shown to be significantly extended by pretreatment with a 3-hr pulse in 4 mM STS, followed by spraying (to runoff) with 30 ppm NAA, followed by a 48-h pulse in a solution containing 10% sucrose, 300 ppm citric acid, and 300 ppm Physan-20 (Mor et al., 1984). This pretreatment is not sufficient to counteract the decrease in vase-life due to even short-term storage and is of no apparent benefit to flowers harvested immature.
Storage Conditions: Store at 0 to 1 ºC (32 to 33.8 °F). Even when pre-treated to prevent flower abscission, Agapanthus flower stalks stored dry at 1 ºC (33.8 °F) suffer significant decrease in vase-life after only 4 days and are frequently unable to achieve a minimally acceptable number of open florets.
Packing: Agapanthus flowers are normally packed in horizontal fiberboard boxes.
Special Considerations: Premature flower fall is caused mainly by ethylene, especially for immature flower buds. The common blue cultivar 'Mooreanus' is much less prone to premature flower fall than the white flowering 'Aldidus.'

LILY, ASIATIC LILY, ORIENTAL LILY
Scientific Name and Introduction: *Lilium spp.* Lilies have long been popular as garden flowers, prized for their stately beauty, and potted white lilies are a tradition in countries that celebrate Easter or Christmas. The brightly colored flowers of hybrid lily cultivars have become increasingly popular as cut flowers and have excellent vase-life, especially if pretreated to prevent effects of ethylene. Buds open well if provided with preservative. Lilium is from the Greek word lirion, used in the naming of certain subdivisions of the genus.
Quality Characteristics and Criteria: Lilies are normally cut when one or two buds are just beginning to "crack." Tight-bud stage flowers take some time to open, and petals of open flowers are likely to be damaged during transport. Most species and cultivars should be purchased with color showing on at least one flower. Avoid bunches with a number of open flowers, since they probably have been held at warmer temperatures during marketing.
Grading and Bunching: Although there are no grade standards for lilies, the number of buds per stem, the stage of maturity, and the color and quality of the foliage are all important quality parameters. Flowers are normally bunched in groups of 5 or 10.
Ethylene Sensitivity: Exposure of lilies to ethylene results in petal abscission, leaf yellowing, and abortion of young buds..
Pretreatments: After harvest, lilies should be treated with STS or 1-MCP to extend their vase-life. Pulsing with a preservative solution containing 10% sucrose can improve subsequent bud opening, and it is also possible to reduce postharvest leaf yellowing in susceptible cultivars by pre-treating them overnight with 2000 ppm GA_3.
Storage Conditions: Lilies should be stored at 0 to 1 ºC (32 to 33.8 °F). If flowers are to be stored for any length of time, they should be treated prior to storage with STS or 1-MCP and an appropriate fungicide, the latter to protect against Botrytis. Lilies can be stored for up to 4 weeks if they are pulsed for 24 h with 1.6 mM STS + 10% sucrose and then stored dry at 1 ºC (33.8 °F). Flowers should be properly pre-cooled, and they must be packaged so that water loss during storage is minimized (wrap pre-cooled flowers in polyethylene film). However, some problems with leaf browning and/or yellowing can occur even after 2 weeks storage.
Packing: Lilies are normally packed in horizontal fiberboard boxes.
Special Considerations: Proper cultivar selection (van der Meulen-Muisers et al., 1997) and the use of anti-yellowing postharvest chemical treatments (available commercially in some markets) can diminish leaf yellowing. STS or 1-MCP only reduce leaf yellowing caused by exposure to ethylene. Lily pollen can stain almost anything; removing stamens containing the pollen does not affect flower life. Some new cultivars do not shed pollen.

LISIANTHUS, PRAIRIE GENTIAN

Scientific Name and Introduction: *Eustoma grandiflora* Introduced into cultivation from Texas, production of lisianthus has increased dramatically recently, spurred by development mostly in Japan, of excellent cultivars with a wide range of colors, and single and double forms.

Quality Characteristics and Criteria: Stems are harvested when at least one flower is open. Although requiring extra labor, removal of immature shoots, whose buds will not develop, improves display quality. Choose stems with at least one open flower and several large buds.

Grading and Bunching: There are no grade standards for lisianthus, but obvious leaf miners and damage to the flower are quality defects. Bunches consist of 10 flower stems.

Ethylene Sensitivity: Lisianthus is slightly sensitive to ethylene - exposure of mature flowers to ethylene will decrease their ultimate vase-life, but the effect is relatively slight, and does not warrant treatment with 1-MCP or STS.

Pretreatments: Lisianthus flowers benefit from sugar in the vase solution, and can respond to pretreatment for 24 h with a preservative containing 5 to 10% sugar (Halevy and Kofranek, 1984).

Storage Conditions: Lisianthus should be stored at 0 to 1 ºC (32 to 33.8 °F).

Packing: Lisianthus flowers are sensitive to gravity, and their stems will bend upwards if the flowers are held horizontal at ambient temperatures. For this reason, lisianthus flowers that will be transported at warmer temperatures are often packed and transported in vertical hampers.

Special Considerations: Lisianthus is sensitive to some of the biocides in preservatives, which may cause browning of the stems. Aluminum sulfate (200 ppm) and Clorox (50 ppm hypochlorite) are excellent bactericides to use with lisianthus.

MARGUERITE DAISY, BOSTON DAISY

Scientific Name and Introduction: *Argyranthemum frutescens* The white or yellow flowers of Margeurite daises are produced year-round outdoors in frost-free areas of California. Borne on a perennial bush, flowers have long been an inexpensive staple for florists, often dip-dyed to provide different colors for special holiday occasions. Their postharvest life is relatively long, but often limited by wilting or yellowing of the foliage. The specific epithet frutescens means bushy.

Quality Characteristics and Criteria: Flowers are considered to be of proper maturity from the time elongating petals are beginning to reflex back from the vertical position until the elongated petals are fully open and the outer ring of stamens ("fuzz") is showing. Marguerites are harvested with shears, and harvesting is an important part of management of the bush-like plants. Flowers are often bunched in the field. The practice of laying finished bunches on the ground after harvest should be discouraged, as it may lead to rotting of flowers and foliage. Quality Marguerites have strong stems, healthy dark green foliage, and several flowers and buds on each stem. Purchase when at least two to three flowers per stem are fully open with no yellow foliage is present.

Grading and Bunching: Marguerites are usually bunched in the field, and the bunch will contain flowers of varying maturity and size. The cost of grading flowers in a packing shed precludes this practice in such a low-return crop. Each bunch has 20 stems, or sometimes 10 stems when sold to supermarkets. Quality marguerites have strong stems, healthy dark green foliage, and several flowers and buds on each stem.

Ethylene Sensitivity: Margeurite daisies, like other members of the Asteraceae, are not affected by exposure to moderate concentrations of ethylene.

Pretreatments: Research has shown improved performance with flowers that are pulsed overnight at 20 ºC (68 °F) with 25 ppm silver nitrate and 0.5% sucrose before storage or transport. Sucrose concentrations above 0.5% can accelerate leaf yellowing and cause leaf injury.

Storage Conditions: Margeurites may be stored at 0 to 1 ºC (32 to 33.8 °F) for 3 days in water or more than 1 week if dry. If flowers are well cooled, dry storage can be in standard daisy hampers.

Packing: Marguerites are normally packed in special "daisy hampers." Flowers are jammed tightly together to increase the number in each package. With present cooling systems, it is almost impossible to

cool flowers packed in this way. Poor postharvest temperature management may explain the development of yellow foliage and foliar disease in marguerites.
Special Considerations: Water in which Margeurites are held often develops a bad odor. Keep solutions fresh and buckets clean. Remove dirt and debris from stems prior to cutting them. Preservative solutions offer varying degrees of benefit depending on brand. Avoid preservative solutions containing 8-hydroxyquinoline citrate or sulfate (generally ones that turn the water slightly yellow). Lower foliage often turns yellow, which can be accelerated by improper storage or pre-cooling and excessive or ineffective preservative solution. White flowers often are submerged in dye to get pink, green, red and blue colors.

ORCHIDS
Scientific Name and Introduction: *Cattleya, Cymbidium,cvs.* and hybrids Additional genera in the plant family Orchidaceae are Dendrobium, Phalaenopsis, Vanda and Paphiopedilum. In addition to their exotic forms and colors, one of the principal attractions of cut orchid flowers is their outstanding longevity. Even out of water, an orchid flower will last for an evening in a corsage. Spikes of cymbidiums will often last a month in a vase.
Quality Characteristics and Criteria: Orchid flowers are usually harvested 3 to 4 days after opening, because flowers cut prematurely will fail to develop normally off the plant. Early and late in the season, individual flowers are cut from the spike as they develop, because prices are high at these times. In mid-season, the whole spike is cut. Virus diseases can be spread from plant to plant during harvest, so cutting tools should be sterilized before being used on the next plant, or disposable razor blades should be used. As individual flowers, purchase when fully open. Spikes should be purchased when at least two flowers per spike are open.
Grading and Bunching: There are no grade standards for orchids. Freedom from defects is a primary measure of quality.
Ethylene Sensitivity: Some genera like Cymbidium and Phalaenopsis, are very sensitive to ethylene; others like Dendrobium are less sensitive.
Pretreatments: Pretreatment with 1-MCP is very effective in preventing the effects of ethylene (Heyes and Johnston, 1998) and increasing the life of orchid flowers and should be standard practice for these flowers.
Storage Conditions: Can range from 0 to 12.5 ºC (32 to 55 °F) depending on cultivar. Many cultivars are not chill sensitive and therefore can be stored as other cut flowers at 0 to 1 ºC (32 to 33.8 °F). If feasible, leaving flowers on the plants at room temperature is a good storage procedure. Be careful not to remove or knock off the pollinia (anthers) as this causes an immediate surge in ethylene production, which in turn causes premature death.
Packing: Because of their fragility and relatively high value, most orchids are packed as individual flowers or spikes, frequently in shredded paper to cushion and protect them from mechanical injury to the blooms. They are then packed 12 to 24 flowers in each carton. Box inserts hold individual water tubes stationary. Shredded wax paper is tucked around and between the flowers for additional protection.
Special Considerations: Only some species and cultivars are ethylene sensitive which explains why anti-ethylene treatments like STS and 1-MCP work only some of the time. The two most common ethylene-induced symptoms are flower discoloration and premature wilting and flower fall. Demand has increased for this species prepared as a corsage and sold through mass market outlets at Easter and Mothers' Day. When sold for corsages the use of water picks filled with fresh-flower solution (not plain tap water) is beneficial.

PERUVIAN LILY, ALSTROEMERIA
Scientific Name and Introduction: *Alstroemeria* cvs., hybrids In the last 20 yr, flowers of various hybrids of species of the genus Alstroemeria, variously called Alstroemeria, Peruvian Lily, or Lily of the Incas, have become an increasingly important part of commercial cut flower trade. Flowers come in a

variety of types and colors. All have a long postharvest life, typically terminated by petal wilting and/or drop and yellowing of the leaves. The Swedish Consul in Spain, KIas Alstroemer, had seeds of this species brought to Europe in 1754. The famous plant taxonomist Carl Linnaeus, a friend of Alstroemer, subsequently named the species after him.

Quality Characteristics and Criteria: For long-distance markets, flowers are harvested when the buds are about to open and start to color. For local market, harvest is delayed until the first three flowers have opened. Flowers are pulled off or cut, depending on the variety. Where pulling may damage the underground parts of the plant (as in young plants of 'Regina'), the stem should be cut. If flowers are cut, the remaining stem should be removed later. At least one flower per stem should be open at time of purchase. Purchase only by cultivar name.

Grading and Bunching: There are no grade standards for alstroemeria, but in addition to the common characters of freedom from damage, stem length, strength and straightness, it is suggested that the flowers in a bunch should be uniform. The flower head should be symmetrical, and leaves should be bright green. The minimum acceptable number of florets per stem varies with cultivar, but is typically 7 to 10.

Ethylene Sensitivity: Alstroemeria flowers are ethylene sensitive.

Pretreatments: Although untreated alstroemeria flowers have a long vase-life; petal drop (particularly a problem if there is ethylene in the environment) can be delayed by pretreatment with 1-MCP or STS. In some cultivars, leaf yellowing occurs before flower senescence. It can be delayed by a pulse treatment with a preservative containing growth regulators (gibberellins (Kappers et al., 1998) or cytokinins).

Storage Conditions: Alstroemeria should be stored at 0 to 1 ºC (32 to 33.8 °F); present information suggests that alstroemeria can readily be stored for up to 1 week at 1 ºC (33.8 °F).

Packing: Alstroemeria are normally bunched in groups of 10, sleeved, and packed in horizontal boxes. Flower pedicels are affected by gravity and will bend upwards when temperature control during storage is poor.

Special Considerations: When re-cutting, remove the whitish or blanched bottom portion of the stem, if present, for maximum solution uptake and life. Leaf removal will reduce vase-life if enough flowers are not present for solution uptake. Since Alstroemeria is a member of the Amaryllidaceae, a botanical family from which many pharmaceutical products are derived, it's not surprising that some humans get allergic dermatitis from this species.

PROTEA, PINCUSHION

Scientific Name and Introduction: Proteaceae family. The family Proteaceae includes a diverse range of species of trees and shrubs in the genus *Protea* from southern Africa and of other genera from Australia whose branches and flowers are used for foliage and as cut flowers. The flowers are normally bird pollinated, and produce copious amounts of nectar, explaining the old Afrikaans name of "sugar bush." The family name refers to the diversity of forms of the flowers. Additional genera are *Banksia*, *Leucospermum*, and *Leucodendron*.

Quality Characteristics and Criteria: Foliages are cut when mature (no soft tips), and the flowers when at least the outer florets are fully expanded. Banskias may be harvested when at least half of the flowers on the cylindrical spike are open. Make sure leaves are not black.

Grading and Bunching: Quality protea flowers and foliage are free of blemishes, and have reasonably long, straight, stems. Foliage such as 'Safari Sunset' leucodendron is bunched in groups of 10, 1, or 25. Flowers are handled individually or in bunches of 5 or 10, depending on quality, size, and market demand.

Ethylene Sensitivity: Neither foliage nor flowers of the proteas are affected by exposure to ethylene.

Pretreatments: Species that are susceptible to leaf blackening may be pre-treated by pulsing overnight at 20 to 25 °C (68 to 77 °F) with 5% sugar (sucrose or glucose) (Dai and Paull, 1995). Higher concentrations may cause leaf blackening.

Storage Conditions: Flowers and foliage from the Proteaceae should be stored at 0 to 1 ºC (32 to 33.8 °F). Rapid pre-cooling, and maintenance of the proper storage temperature is an important tool in

preventing leaf blackening that is a common postharvest problem in proteas. Care must be taken to ensure that there is no condensation or free water on leaves during storage as this greatly increases the incidence of blackening.
Packing: Proteas are normally packed in horizontal fiberboard boxes.
Special Considerations: Leaves turn black due to lack of carbohydrate (food) and warm temperatures. Use preservative solutions and proper low temperature management to prevent leaf blackening. In addition, this disorder can be reduced if the flowers are held under lighted conditions. Leaf blackening is not due to low temperature (chill disorders), nor is it due to poor water relations. Many species and cultivars can be easily dried or preserved by just allowing them to dry under warm, low RH conditions.

ROSE, SPRAY ROSE, SWEETHEART ROSE
Scientific Name and Introduction: *Rosa* cvs., hybrids. The rose undoubtedly remains the queen of the cut flowers. The historical association of this flower with romance and beauty ensures that roses will continue to be a highly desired cut flower in the future. Properly handled, most of the commercial cut roses will easily last in the vase for 10 days. Unfortunately, many consumers consider roses to have a very short vase-life. This is partly because poor water uptake by certain cultivars of purchased roses all too often results in the symptom called "bent neck" in which the flower neck wilts, and the bud fails to open. We also have found that many commercial cultivars are quite sensitive to ethylene gas. The cut flower industry has an important stake in overcoming the poor postharvest reputation of the cut roses. All that is required is proper postharvest care for those cultivars susceptible to bent neck, and appropriate pre-treatment of those that are sensitive to ethylene, especially if they are to be sold in supermarkets or other ethylene polluted areas.
Quality Characteristics and Criteria: Roses are harvested at different levels of maturity, depending on marketing and cultivar. For long-distance transport or storage, roses should usually be harvested with some of the sepals reflexed. Flowers harvested before the sepals reflex may fail to open, or may be more susceptible to bent neck. Fast-opening roses, like some yellows and whites, should be harvested just before the sepals start to separate from the bud. The marketing life of roses harvested later will be reduced unless extra care is taken with their postharvest handling. Harvesting is most convenient using shears provided with auxiliary jaws to hold the bloom after harvest. The cut is normally made so as to leave 2 five-foliate leaves below the cut. When stem length is an important consideration, the cut may be made below Roses should be purchased and sold by cultivar name. Avoid blooms that are already open; flowers should normally have some or all of their sepals (the green protective leaves at the base of the flower) folded back, but the petals should not have started unfolding. Brown spots or patches on the outer petals may be an indication of Botrytis infection.
Grading and Bunching: Objective grading is based on stem length; subjective grading is based on flower maturity, stem straightness, stem caliper, and quality of flower and foliage. Defects on the outer "guard" petals are not normally a cause for down-grading, because these petals are removed by the retail florist. Leaves and thorns may be removed manually or mechanically if desired. This operation has little effect on vase-life if flowers are placed in an effective preservative. The number of stems per bunch, and bunch pattern (single layer, staggered two-layer) depends on market preferences.
Ethylene Sensitivity: Some cultivars are ethylene sensitive. Treat with 1-MCP or STS if they are being distributed through the mass markets, especially if being shipped through distribution centers, and also treat to prevent the effects of the ethylene prior to dry storage.
Pretreatments: Roses should be pre-treated with 1-MCP or STS to prevent the effects of ethylene, especially if they will be sold through a supermarket. Sugar-containing pre-treatments are not particularly useful for roses. Re-hydrate after cutting, storage, and on arrival at the retail outlet with a re-hydration solution. Commercial re-hydration solutions are effective, or you may use clean water containing 50 ppm hypochlorite, preferably below pH 5.0. This solution has proved safe, and is inexpensive, so the buckets can be filled to the desired 20 to 30 cm (8 to 12 in) deep (Reid et al., 1996).
Storage Conditions: Roses should be stored dry at 0 to 1 ºC (32 to 33.8 °F). Roses intended for long-

term storage should be packed in polyethylene-lined cartons and pre-cooled. They may be held for up to 2 weeks in dry storage if the temperature is maintained close to the freezing point.

Packing: Rose bunches are routinely sleeved in plastic, waxed paper, or soft corrugated card sleeves. The 'spiral' bunch used by many off-shore producers increases the difficulty of pre-cooling the flowers, and the opportunity for condensation collecting on the outer petals. Botrytis infection is a common result of the presence of free moisture on the petals of cut roses.

Special Considerations: Removal of those leaves and thorns below the water line should not reduce vase-life if stems are placed into a preservative solution. The fungus Botrytis represents a major problem for roses. Symptoms of Botrytis infection include brown blotches on petals and gray, fuzzy growth on leaves, stems or flowers. Postharvest fungicide dips can be helpful - use only registered products according to label instructions. Petal blackening on some red cultivars is due to growing conditions, and cannot be corrected at wholesale or retail levels.

SNAPDRAGON

Scientific Name and Introduction: *Antirrhinum majus* cvs. The many pastel flower colors of the tall spikes of snapdragons allow florists and consumers innumerable design options. Snapdragons used to be considered very sensitive to ethylene, but the newer cultivars have been selected for ethylene resistance, and ethylene normally causes a problem only when present in moderate concentrations. Flower drop (shattering) occurs in 24 h if ethylene is present in air at ≥ 0.5 ppm. Antirrhinum is Greek for "like" and "nose" in reference to the flower shape.

Quality Characteristics and Criteria: For local sales, snapdragons are typically harvested when flowers on the lower ½ to ⅔ of the spike are open. A less mature stage is desirable for shipping and/or short term storage. Purchase those cultivars that are less sensitive to ethylene. At least two to five florets per stem should be open. Avoid flowers with excessive stem bending and yellowing foliage, which indicate poor temperature management after harvest.

Grading and Bunching: Snapdragons are bunched in groups of 10 by color. Flowers must have straight stems and healthy foliage. Foliage on the lower ⅓ of the stem should be removed.

Ethylene Sensitivity: Most snapdragon cultivars are sensitive to ethylene. Older flowers on a stem are more susceptible to ethylene than younger ones. However, some cultivars are naturally ethylene resistant and, therefore, respond little to treatment with 1-MCP or STS.

Pretreatments: Treatment with 1-MCP or pulsing with STS protects snapdragon flowers from ethylene-induced shattering. Snapdragons also benefit from an overnight pulse at 20 ºC (68 °F) with a preservative fortified with 7% sucrose. Upper flowers on spikes treated in this way open with better color than control flowers. Snapdragons are best stored with only a few flowers open, but this often results in poor development of the flowers on the spike and fading of color at the tip. Spikes cut with only one or two flowers open should be opened in a solution containing 300 ppm 8-hydroxyquinoline citrate (8-HQC) and 1.5% sucrose. This bud-opening solution can also be used as a vase solution. Addition of 25 ppm of the growth regulator n-dimethylamino succinamic acid (Alar, B-nine) increases flower quality and also counteracts the excess spike length that sometimes results from placing snapdragons in 8-HQC and sucrose. Pulse treatments with naphthylpthalamic acid or Ca^{++} antagonists (Philosoph-Hadas et al., 1996) can reduce geotropic curvature that results from horizontal storage at warmer temperatures.

Storage Conditions: Snapdragons can be stored at 0 to 1 ºC (32 to 33.8 °F) for 7 to 10 days if they are wrapped in polyethylene film to retard moisture loss. Snapdragons have been satisfactorily stored for up to 3 weeks at -1 ºC (30.2 °F). For long-term storage, bud-harvested flowers should be used. Bud-harvested flowers are ones in which the bottom two or three florets have colored petals emerging about one-quarter of an inch above the calyx. Snapdragons are relatively sensitive to ethylene gas. Flowers on harvested spikes assume a permanent, upward bend, thus reducing quality, if held at warmer temperatures for even a short time in a non-vertical position. Snapgragons should always be stored and shipped upright in snapdragon hampers at low temperatures. Pretreatment with naphthyphthalamic acid can overcome this bending, but it is not registered for this purpose.

Packing: Snapdragons are usually packed upright in hampers or Proconas, which reduce the likelihood of geotropic bending. If flowers are properly pre-cooled and transported at optimal temperature (0 to 1 ºC; 32 to 33.8 °F) they can be packed in a normal horizontal flower box.
Special Considerations: Do not remove more leaves than necessary, as this can stimulate flower fall. Do not use any home brews, ex., anti-freeze, as replacements for preservative solutions. The many pastel flower colors allow florists and consumers innumerable options. The flower can be made to snap shut after separating and releasing the two-lipped corolla (fused petals). When grown as a garden plant, treat them as an annual although many will respond as a perennial, depending on location and cultivar.

STATICE, GERMAN STATICE
Scientific Name and Introduction: *Limonium spp., Goniolimon.* A traditional filler flower, the standard statice (*Limonium sinuatum*) comes in a range of pastel colors, and is widely used both fresh and dried. Other species of *Limonium* are sold in the trade as german, latifolia, sea foam and caspia statice. Hybrid Limonium cultivars, grown from tissue culture, have become very popular in recent years. Their vase-life is greatly improved by pretreatments to prevent the effects of ethylene and to improve bud opening.
Quality Characteristics and Criteria: Standard statice is harvested fully open, but before the true flowers (small white flowers within the brightly colored bracts) senesce. Hybrid statice cultivars should be harvested when the first flower on each spike is open. Avoid bunches where flowers have yellowing stems and leaves, and bunches with obvious fungal growth or wilted flowers. Remove from shipping boxes and re-cool flowers immediately. Also remove stem ties and separate stems to improve air circulation and reduce the likelihood of Botrytis infection.
Grading and Bunching: Quality statice is of the correct maturity, and is free of defects and disease. Standard statice is normally bunched in groups of 25; other cultivars are bunched by bunch size. Sleeves help to prevent tangling of the delicate branchlets.
Ethylene Sensitivity: Statice flowers are sensitive to ethylene, which causes accelerated wilting. In standard statice, this effect is not apparent since the "flowers" are papery bracts surrounding the true flowers. In hybrid statice cultivars, effective treatments to inhibit action of ethylene improve flower quality and vase-life.
Pretreatments: Hybrid statice benefits enormously from pretreatment with STS or 1-MCP, and pulse pre-treatment with a sugar solution containing 10% sugar and 200 ppm Physan-20 for 12 h. Sucrose present in the preservative extends the life of individual florets, and promotes flower opening, resulting in up to 3-fold increases in longevity of inflorescences (Burge et al., 1998).
Storage Conditions: Store all statice at 0 to 1 ºC (32 to 33.8 °F); when flowers are infected with Botrytis, even short-term storage can greatly reduce life.
Packing: Statice is normally packed in horizontal fiberboard boxes.
Special Considerations: Many statice species can be dried and used for years in permanent flower arrangements. Yet, when used as a fresh flower, they may last only a few days before leaf yellowing (on statice only, not German statice) or Botrytis infestation occurs. Storing statice under lights can retard leaf yellowing, but this may be hard to do in commercial practice.

STOCK
Scientific Name and Introduction: *Matthiola incana* A very traditional field flower with spikes of aromatic flowers in a wide range of colors, stock continues to be a staple floristry item. Somewhat sensitive to ethylene and prone to bacterial contamination of the vase solution, stock flowers respond to proper postharvest care. The species is named after Dr. Peter Andrew Matthioli, an Italian physician and botanist, 1500 to 1577. The specific epithet incana means hoary (hairy) in reference to the plant's whitish fuzz or hair.
Quality Characteristics and Criteria: Stock should be harvested with no fewer than six open florets on each spike. To increase stem length growers may pull the plants from the ground and remove the roots later. Flowers harvested and sold with at least six flowers open per stem generally perform better than

ones harvested and sold with less open flowers. Avoid spikes with bruised, brown or infected florets and/or yellowed leaves.
Grading and Bunching: Quality stock have long straight spikes of uniform unblemished flowers and free of defects.
Ethylene Sensitivity: Exposure to ethylene results in water soaking of the petals, accelerated senescence of the florets, and epinasty (downward curvature) of the leaves.
Pretreatments: To prevent deleterious effects of ethylene, stock should be pretreated with 1-MCP or STS.
Storage Conditions: Stock should be stored at 0 to 1 ºC (32 to 33.8 °F).
Packing: Stock are frequently packed in hampers or aquapacks, but may also be packed in horizontal fiberboard boxes.
Special Considerations: Water uptake can be reduced in flowers harvested with the roots. Use a preservative solution to keep the growth of microorganisms in check. As with baby's-breath and Marguerite daisy, the vase and bucket solutions can develop a very unpleasant smell if the correct amount and type of preservative solution is not used and if buckets are not properly sanitized.

SUNFLOWER
Scientific Name and Introduction: *Helianthus annuus* In recent years, smaller cultivars of sunflower have become a very popular florist item, and a range of forms and colors are now widely available. Helianthus is derived from the Greek "helios," the sun, and "anthos," a flower.
Quality Characteristics and Criteria: Sunflowers are normally harvested when the petals (the outer flowers or ligules) have unfolded and are at least vertical. For local market, flowers are harvested with ligules fully expanded and horizontal. No yellow, wilted leaves should be present. Storage-life is often determined more by leaf yellowing or desiccation than by flower problems.
Grading and Bunching: Quality sunflowers are of uniform maturity, free from defects, have straight stems, and good quality foliage. Smaller-flowered cultivars may be bunched in groups of 10 or 12, and large-flowered types are normally packed individually.
Ethylene Sensitivity: Prolonged exposure of sunflowers to low concentrations of ethylene results in abscission of ligules.
Pretreatments: The tendency for sunflowers to wilt prematurely in the vase can be avoided by pre-treating flowers for 15 to 30 min with clean water containing 0.02% detergent, such as Tween-20, Triton X-100, or dishwashing detergent (Jones et al., 1993).
Storage Conditions: Sunflowers can safely be stored at 0 to 1 ºC (32 to 33.8 °F).
Packing: Sunflowers are normally packed in standard horizontal flower boxes.
Special Considerations: Sunflowers are also somewhat sensitive to gravity. If held horizontal at warmer temperatures the flower heads will be permanently bent down, so it is important to maintain cool temperatures during transport and storage.

SWEET PEA
Scientific Name and Introduction: *Lathyrus odoratus* Once important cut flowers, prized for their aroma and range of colors, sweet peas benefit substantially from anti-ethylene pretreatments. Combined with a sugar pulse, treatment with STS or 1-MCP enables these delicate flowers to be harvested at an earlier stage when the flowers are less susceptible to damage, and to give as much as 1 week of display life.
Quality Characteristics and Criteria: Sweet peas are traditionally harvested when the last bud on the stem is about half open. "Bud-stage" flowers are harvested when the petals on the first bud are colored and near full size, but have not yet opened. Flowers are harvested by holding the stem between the thumb and forefinger near the base (supporting the vine with two fingers behind and one in front) and then pulling the flower backwards and upwards from the axil of the leaf. Sweet peas should have five flowers per stem, with only one flower open at the time of purchase. Avoid bunches with wilting flowers or where

buds or flowers have fallen.
Grading and Bunching: There are no grade standards for sweet peas, but quality flowers have long, straight stems and at least five buds on each spike. Flowers can be bunched by color, or in mixed colors, in bunches of 10.
Ethylene Sensitivity: Exposure to ethylene results in accelerated wilting of petals, abscission of flowers, and failure of developing buds to open.
Pretreatments: Proper pretreatment greatly improves the vase-life of sweet peas. Flowers should be treated with 1-MCP or STS (Sexton et al., 1995), then placed in a preservative solution containing 4% sucrose at 20 ºC (68 °F) overnight.
Storage Conditions: Sweet peas should be stored at 0 to 1 ºC (32 to 33.8 °F). Flowers that have been pretreated with 1-MCP and sucrose will open well and have a satisfactory vase-life after storage for up to 1 week at 1 ºC (33.8 °F).
Packing: Sweet peas are packed in horizontal boxes or hampers.
Special Considerations: Cultivars vary in the intensity of their aroma, one of the characteristic and appealing features of sweet peas.

SWEET WILLIAM
Scientific Name and Introduction: *Dianthus barbatus* A close relative of carnation, normally grown in the field, Sweet William flowers are borne on a short-stemmed inflorescence. Colors range from white through intense red and purple, and provide strong accents in an arrangement. The specific epithet barbatus means bearded or barbed in reference to the beard-like growth emerging from the petals.
Quality Characteristics and Criteria: Flowers in the Sweet William inflorescence continue developing after harvest and they should be harvested with the outer ring of flowers open. Flowers should have at least the outer whorl of florets open. Avoid flowers with withered or sleepy florets, as this indicates ethylene-induced problems.
Grading and Bunching: Quality Sweet William flowers are of uniform maturity, are free from damage and evidence of pests and diseases, have reasonable stem length and good quality foliage. Flowers are sold in a grower's bunch of at least 12 stems.
Ethylene Sensitivity: Flowers are ethylene-sensitive.
Pretreatments: Flowers should be pretreated with 1-MCP or STS to prevent effects of ethylene.
Storage Conditions: Like carnation, flowers should be stored at 2 to 3 ºC (35.6 to 37.4 °F).
Packing: Sweet William flowers are normally packed in horizontal fiberboard boxes.
Special Considerations: As with many flowers grown in the field, fungal infections due to the wet foliage and flower conditions sometimes experienced at harvest can be a problem. Make sure flowers are rapidly unpacked and aerated to reduce possible disease spread.

TUBEROSE
Scientific Name and Introduction: *Polianthes tuberosa* Spikes of ivory flowers much prized in the East for their fragrance and by western florists for accents and bridal bouquets, tuberose flowers bear as many as 50 florets, in pairs, on a tall spike. The postharvest life of these flowers typically is limited by failure of developing buds to open, so that the life is determined by the life of the flowers that were open at harvest. Proper pre-treatments can greatly extend the life of tuberose, and should routinely be carried out with flowers intended for storage and transport.
Quality Characteristics and Criteria: The flowers are normally harvested with two to four open blooms on the spike. Although earlier harvest provides a spike that is more resistant to transportation, the buds are unlikely to open after transport unless properly pre-treated. Flowers for the local market may be harvested with more open flowers on the spike. It is unfortunately difficult to determine whether tuberose flowers have been effectively pre-treated prior to purchase. Look for straight stems, unblemished blooms, and work with your supplier to ensure that the flowers have been properly pretreated.
Grading and Bunching: Tuberose are sold in bunches of 10 stems.

Ethylene Sensitivity: Floret opening is reduced in spikes exposed to high concentrations of ethylene, but this effect is probably not normally of commercial significance, so 1-MCP or STS treatments are not warranted for tuberose.
Pretreatments: Tuberose flowers should be pulsed for 24 h at 20 to 25 °C (68 to 77 °F) with a preservative solution augmented with 20% sucrose (Naidu and Reid, 1989). This pretreatment will significantly improve vase-life and opening of buds on the flower spikes. Flowers to be pre-treated in this way should preferably be harvested dry, graded, bunched, and re-cut, then placed immediately in the pulsing solution.
Storage Conditions: The optimal temperature for cooling and storage of tuberose is 0 ºC (32 °F), but after only short periods, the buds on the spike fail to open. Pulse pre-treatment with sucrose overcomes this problem, and after 6 days storage, flowers open as well as freshly-cut spikes.
Packing: Tuberose may be packed in hampers or in horizontal fiberboard boxes. If packed horizontal, they should be held at the proper temperature to avoid geotropic curvature.
Special Considerations: Florists often use individual tuberose blooms in corsages and boutonnieres. Proper pre-treatment of the spikes will ensure continued opening of the blooms in the florists' workroom and consequent increased utility of each spike.

TULIP
Scientific Name and Introduction: *Tulipa cvs., hybrids* Tulips, one of the classical cut flowers, were the source of tremendous interest when they were first brought to Holland from the Mediterranean countries where they are native. The most common species, Tulipa gesnerana, was named after C. Gesner, a botanist who lived from 1516 to 1565.
Quality Characteristics and Criteria: The entire tulip plant, with bulb attached, is harvested when the tepals show 50% color. It is preferable to harvest in the early morning when temperatures are lower, and to cool the harvested flowers immediately. Purchase when flower color is just visible and only by cultivar name since postharvest characteristics vary greatly.
Grading and Bunching: Tulip blooms are graded for uniform maturity (degree of opening), stem length, and freedom from defects. Defects include flower bud blasting, greening of flower buds, and toppling. Bulbs are then removed, and the bases of stems are cut to ensure adequate water uptake. Tulips are typically bunched in groups of 10.
Ethylene Sensitivity: Tulips show no response to ethylene, nor any response to inhibitors of ethylene actions or synthesis (Sexton et al., 2000).
Pretreatments: No pretreatments are required for tulips.
Storage Conditions: Tulips should be stored at 0 to 1 ºC (32 to 33.8 °F) with 85% RH, upright to prevent stem bending, and with bulbs attached. It has been reported that flowers stored dry in bunches can keep up to 7 weeks if sealed in polyethylene bags or kept in boxes over-wrapped with polyethylene. Desiccation of tulips can be a serious problem, causing collapse of the stem below flowers. Control of RH and proper re-hydration following storage can minimize the problem.
Packing: Tulips may be packed in hampers or in regular fiberboard flower boxes. Stems and blooms should be securely wrapped to prevent bruising and breakage. Tulips packed horizontally must be held at proper temperature of 0 to 1 ºC (32 to 33.8 °F) to avoid gravity-induced bending.
Special Considerations: End-user life is very species and cultivar dependent, as is the flower maturity stage when sold. Some people may get dermatitis from continual handling of tulip flowers. Preservative solutions are recommended; benefits vary from 0 to 150% increase in vase- life, depending on cultivar, flower food brand, and water quality. Do not place in the same bucket with daffodils that have been just re-cut, as the mucilage exuded by daffodils can reduce the vase-life of tulips. Tulip flower stems (scapes) often continue to elongate after harvest and will often grow out of the arrangement. Stems should be maintained in an upright position during handling to prevent stem bending.

WAXFLOWER, GERALDTON WAXFLOWER

Scientific Name and Introduction: *Chamelaucium uncinatum* A native to Western Australia, the 'Geraldton' waxflower is available in shades of white through deep purple, and has become an important "filler" material. It is produced in substantial quantities in Israel and more recently in Australia and California. Various techniques have been developed to manipulate the flowering season, and the availability of substantial volumes from the Southern Hemisphere makes waxflower an item that is commonly available in the trade. The major postharvest problems are the shattering of flowers and petals, an ethylene-related problem that can be controlled by pre-treating the flowers with 1-MCP or STS, and Botrytis infection, particularly an issue for growing areas with erratic rainfall. Fungicide dips have successfully been used as a control measure. The specific epithet 'uncinatum' means hooked at the point, in reference to the leaves which are hooked at their ends. The crushed leaves give a pleasing citrus aroma.

Quality Characteristics and Criteria: Wax flowers are normally harvested with a mixture of open flowers and mature buds on each branchlet. Branches are harvested to maximize stem length without compromising the following year's crop. Avoid buying if leaves or flowers have fallen off or are turning yellow.
Grading and Bunching: There are no grade standards for the flowers, which are sold in field bunches. Quality waxflowers have numerous flowers on long stems, and dark-green unblemished foliage. Waxflower bunches from Australia weigh 300 g per bunch, whereas California bunches usually weigh 400 g.
Ethylene Sensitivity: Waxflowers are very sensitive to ethylene, which causes loss of flowers, buds and leaves (Joyce, 1993).
Pretreatments: Harvested wax flower bunches should be treated with 1-MCP or STS in the same way as carnations.
Storage Conditions: Store waxflower at 0 to 1 ºC (32 to 33.8 °F). If properly pre-cooled and subsequently wrapped in plastic to reduce water loss, flowers can be stored dry for up to 2 weeks at 1 ºC (33.8 °F). There is no benefit of wet over dry storage, and dry storage is therefore the method of choice. The main problem during storage is from growth of Botrytis on flowers. Dipping in 1% Rovral (Ipridione) solution prior to storage can prevent Botrytis infection.
Packing: Waxflowers are packed in bunches that contain variable numbers of stems (around 10) to provide a satisfactory bunch.
Special Considerations: The major storage problems are flower shatter (flowers fall off) and premature leaf yellowing and desiccation. Treat with anti-ethylene treatments like STS. Leaf yellowing cannot be controlled with STS or other commonly available preservatives.

YELLOW ASTER
Scientific Name and Introduction: *x Solidaster luteus* The "x" prior to the generic name indicates that this species is an inter-generic hybrid, the result of crossing two different genera (*Aster* and *Solidago*). The specific epithet luteus means yellow. Originated in the Leonard Lille Nursery located in Lyon, France (1910).
Quality Characteristics and Criteria: At least 50% of the flowers should be open. Avoid old product, as leaf yellowing and desiccation can be troublesome.
Grading and Bunching: As with other filler flowers, bunches are made by size or weight.
Ethylene Sensitivity: Like other Asteraceae, solidaster flowers are not sensitive to ethylene.
Pretreatments: Like *Solidago*, solidaster flowers probably would benefit from a cytokinin pulse treatment to delay leaf yellowing {Philosoph et al. 1995}.
Storage Conditions: Solidaster should be stored at 0 to 1 ºC (32 to 33.8 °F).
Packing: N/A
Special Considerations: If flowers are too immature when harvested, they may not develop to their maximum beauty. Treat like most other members of the chrysanthemum family. Leaves should be stripped from the stem as they rot underwater and will foul the vase solution. Make sure that buckets,

vases, and solution are kept clean.

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